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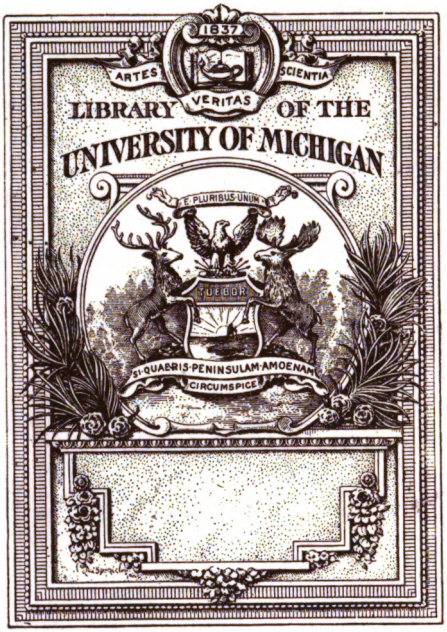

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THE

Mineralogical Magazine

AND

JOURNAL

OF THE

MINERALOGICAL SOCIETY.

VOLUME XI.

LONDON:
SIMPKIN, MARSHALL, HAMILTON, KENT & Co., LIMITED,
STATIONERS' HALL COURT.

MDCCCXCVII.

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LONDON:

PRINTED BY WILLIAMS AND STRAHAN,

7 LAWRENCE LANE, CHEAPSIDE.

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TABLE OF CONTENTS.

PAGE

A Chemical Study of Some Native Arsenates and Phosphates. 1. Euchroite. 2. Liroconite. 3. Clinoclase. 4. Tyrolite. 5. Pharmacolite. 6. Cacoxenite. 7. Kühnite. By A. H. Church, M.A., F.R.S. 1

A Basic Ferric Sulphate, from Parys Mount, Anglesey. By A. H. Church, F.R.S. 13

Occurrence of Mispickel in the Stewartry of Kirkcudbright. By P. Dudgeon, F.R.S.E. 15

Augelite. By G. T. Prior, M.A., F.G.S., and L. J. Spencer, B.A., F.G.S. 16

A Note on Cone-in-Cone Structure. By Professor T. G. Bonney, D.Sc., LL.D., F.R.S., &c. 24

On the Occurrence of Delessite in Cantyre. By Professor Heddle and Mr. Stuart Thomson 28

Obituary. Patrick Dudgeon, F.R.S.E. 30

Notes and Comments 32

Review 34

Abstracts 35

On the Structure-Planes of Corundum. By Professor John W. Judd, C.B., LL.D., F.R.S., &c. 49

On some simple Massive Minerals (Crystalline Rocks) from India and Australia. By Professor John W. Judd, C.B., LL.D., F.R.S., &c. 56

172915

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PAGE

On an Accurate Method of determining the Densities of Solids. By the Earl of Berkeley, F.G.S. 64

Enargite. By L. J. Spencer, B.A., F.G.S. 69

Lewisite and Zirkelite, two new Brazilian Minerals. By Dr. E. Hussak, and G. T. Prior, M.A., F.G.S. 80

Obituary. James Dwight Dana 89

Notes and Comments 91

Reviews 93

Abstracts 100

On Homogeneous Structures and the Symmetrical Partitioning of them, with application to Crystals. By William Barlow 119

On the Humite Series. By Professor W. J. Lewis, M.A. 137

Notes on a biotite-cyanite-cordierite-rock from the Upper Satlej Valley, N.W. Himalayas. By Lieut.-General C. A. McMahon, V.P.G.S. 141

Notes and Comments 146

Obituary. Alexander Henry Green, F.R.S. 147

Reviews 148

Abstracts 151

Note on the Occurrence of Rocks allied to Monchiquite in the Island of Fernando Noronha. By G. T. Prior, M.A., F.G.S. 171

On Derbylite, a new Antimono-titanate of Iron from Tripuhy, Brazil. By Dr. E. Hussak and G. T. Prior, M.A., F.G.S. ... 176

On the Chemical Composition of Zirkelite. By G. T. Prior, M.A., F.G.S. 180

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PAGE

The "Satin Spar" of Alston in Cumberland; and the Determination of massive and fibrous Calcites and Aragonites. By L. J. Spencer, M.A., F.G.S. 184

Zinckenite and Wolfsbergite (Chalcostibite) from Wolfsberg in the Harz; and the Zinckenite Group. By L. J. Spencer, M.A., F.G.S. 188

The Crystallography of Plagionite: New Crystal Forms on Stephanite, Enargite and Anglesite. By L. J. Spencer, M.A., F.G.S. 192

An Occurrence of Prehnite in Wales. By W. Jerome Harrison, Junr. 198

On the Micas of the Three Rock Mountain, Co. Dublin. By Professor J. P. O'Reilly 199

On Nemalite from Afghánistán. By F. R. Mallet..... 211

Note on Altaite from Burma. By Henry Louis, M.A., A.R.S.M., F.I.C., F.G.S. 215

Notes and Comments 217

Reviews 219

Abstracts 224

On some British Pseudomorphs. By H. A. Miers, M.A., F.R.S. 263

The Identity of Andorite, Sundtite and Webnerite. By G. T. Prior, M.A., F.G.S., and L. J. Spencer, M.A., F.G.S. 286

On Tripuhyite, a new Antimonate of Iron, from Tripuhy, Brazil. By Dr. E. Hussak and G. T. Prior, M.A., F.G.S..... 302

Monazite and Xenotime in European Rocks. By Orville A. Derby, F.G.S. 304

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PAGE

On Blödite from the Punjab Salt Range. By F. R. Mallet 311

On a new occurrence of Apophyllite in South Africa. By J. A. Leo Henderson, M.E. 318

A List of New Mineral Names. By L. J. Spencer. M.A., F.G.S. 323

Abstracts 338

Notes and Comments 345

Obituaries. Gustav Adolf Kenngott 346
Samuel Haughton 347

Index 349

Errata 359

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THE MINERALOGICAL MAGAZINE
AND
JOURNAL
OF THE
MINERALOGICAL SOCIETY.

No. 49. APRIL, 1895. Vol XI.

A Chemical Study of Some Native Arsenates and Phosphates.

1. Euchroite. 2. Liroconite. 3. Clinoclase. 4. Tyrolite. 5. Pharmacolite. 6. Cacoxenite. 7. Kühnite.

By A. H. Church, M.A., F.R.S.

[Read June 19th, 1894.]

THE present series of notes is mainly based upon analyses executed during the years 1867-1877, but these have been supplemented in a few instances by recent work. The series may be regarded as a continuation of several papers published from time to time in the *Journal of the Chemical Society*, in the *Chemical News*, and in the *Proceedings of the Royal Irish Academy*. Throughout these inquiries particular attention has been paid to the degree of tenacity with which the water present in the hydrous species is held.

1. Euchroite.

A fine specimen of this mineral from Libethen, Hungary, was submitted to analysis in the year 1874. As the results simply confirmed the

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accepted composition of the species, they remained unpublished. But, on looking lately into the record of my analysis, I noted the hitherto unrecorded presence of phosphoric acid in this mineral. As the observation is of interest in connection with other native arsenates, and offers a parallel to the partial replacement of phosphorus by arsenic in some mineral phosphates, a brief note on the subject may be not unacceptable to mineralogists.

The specific gravity of the specimen was 3·42 at $\frac{16°·5}{15°·5}$C. This determination was made in alcohol of sp. gr. ·8892 at 16°·5. The balance used was an assay balance by the late L. Oertling, and was specially arranged for the purpose of taking specific gravities. The crystal of euchroite employed weighed ·4639 gram.

The following figures represent the analytical results with the corresponding percentages :—

Euchroite taken	·7365 gram			
Water lost *in vacuo*	·009	,,	= 1·22	per cent.
Water lost at 100° C. ...	·014	,,	= 1·90	,,
Water lost at low redness ...	·119	,,	=16·16	,,
Water, total	·142	,,	=19·28	,,
Cupric oxide	·3481	,,	=47·26	,,
2 $MgNH_4AsO_4$, H_2O	·376	,,	=30·90	,, As_2O_5
$Mg_2P_2O_7$	·017	,,	= 1·48	,, P_2O_5
Undetermined			1·08	,,

The formula of euchroite, 4 CuO. As_2O_5. $7H_2O$, as deduced from the analysis of Kühn and Wöhler, is in accord with the percentages given in the present note. For the purpose of comparison, I have converted the percentage of P_2O_5 into its equivalent of As_2O_5 :—

	Theory		Experiment
4CuO	47·12 per cent.	...	47·26 per cent.
As_2O_5	34·16 ,,	...	33·29 ,,
$7H_2O$	18·72 ,,	...	19·28 ,,

It might be argued that the loss of water *in vacuo* and at 100° indicates the existence in this mineral of one molecule of cupric hydrate. This loss does indeed correspond pretty nearly to that demanded by such a formula as

$$3CuO.\ As_2O_5.\ 6H_2O + CuO.\ H_2O,$$

if we deduct a small quantity—something less than 0·5 per cent.—of accidental or hygroscopic moisture. But if one-fourth of the copper present in euchroite exist in the form of cupric hydrate, it is hardly likely that the

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mineral would become yellowish-green and not blacken on being strongly heated. One may, however, affirm that one of the seven molecules of water in this mineral is less firmly retained than the remaining six. It is worth while comparing the theoretical and experimental percentages of water corresponding to 1 and to 6 molecules:—

	Theory	Experiment
H_2O	2·67	3·12
$6H_2O$	16·05	16·16

2. Liroconite.

A fine specimen of Cornish liroconite was analysed in 1874. Its specific gravity, determined with the same precautions as those observed in the case of euchroite, proved to be 2·97 at $\frac{16°·5}{15°·5}$ The analysis, though incomplete, shows that the water in this mineral is not all retained with equal tenacity:—

Liroconite taken	·812 gram		
Water lost *in vacuo*	·052 ,,	= 6·40 per cent.	
Water lost at 100° C. ...	·080 ,,	= 9·85 ,,	
Cupric oxide	·2983 ,,	=36·73 ,,	
2 $MgNH_4AsO_4$, H_2O	·320 ,,	=23·85 ,,	As_2O_5
$Mg_2P_2O_7$	·013 ,,	= 1·02 ,,	P_2O_5

These results, so far as they go, are not inconsistent with the percentages demanded by the expression $4CuO.\ Al_2O_3.\ As_2O_5.\ 13H_2O$. In this formula $3H_2O$ correspond to 6·12 per cent. water, which may be represented by the loss suffered by liroconite *in vacuo*. Similarly, the further loss of 9·85 per cent. sustained at 100° may indicate the separation of $5H_2O$, which theoretically demands 10·19 per cent. The formula above given requires the following percentages:—

$4CuO$	=317·2=35·92	per cent.
Al_2O_3	=102·0=11·35	,,
As_2O_5	=230·0=26·04	,,
$13H_2O$	=234·0=26·49	,,

Although these theoretical numbers agree fairly with the analytical results hitherto published, the empirical formula which they suggest

$$\left.\begin{matrix} 3CuO.\ As_2O_5 \\ CuO.\ H_2O \\ Al_2O_3.\ 3H_2O \end{matrix}\right\} 9\ aq$$

is not in precise accord with the losses of water which this mineral suffers

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in vacuo and at 100°. As I have pointed out elsewhere,[1] the native normal aluminium hydrate, gibbsite, loses no water *in vacuo* or even at 100° : this observation does not lend support to the view that $Al_2O_3 . 3H_2O$ exists as such in liroconite. Reasoning from the analogy of variscite, a normal native aluminium phosphate, which loses all its water at 100°, it might be concluded that a corresponding aluminium arsenate exists in liroconite : if this be the case, the formula for this species might be written :—

$$\left.\begin{matrix} Al_2O_3 . As_2O_5 . 4H_2O \\ 4(CuO . H_2O) \end{matrix}\right\} 5H_2O$$

Unfortunately it is not possible to bring the loss of $3H_2O$ *in vacuo*, and of $5H_2O$ at 100°, into harmony with this expression. So, for the present and until further experimental evidence has been accumulated, we must be content with such a formula as this[2] :—

$$4CuO . Al_2O_3 . As_2O_5 . 5H_2O + 5H_2O + 3H_2O$$

3. Clinoclase.

The mineral clinoclase had been analysed with concordant results by Rammelsberg and by Damour when, in the year 1867, I came into possession of a particularly fine specimen. In studying the group of arsenates and phosphates to which this species belongs, I was anxious to ascertain the degree of tenacity with which the water present in the mineral was retained. I found that *in vacuo* and at 100° C. the finely powdered substance lost no more than ·08 per cent. of moisture. This having been deducted, the percentages of constitutional water, of arsenic pentoxide, and of cupric oxide were determined to be :—

	Experiment.	*Theory.* $3CuO . As_2O_5 . 3(CuO, H_2O)$
Water (by difference) ...	7·20	7·11
Arsenic pentoxide ...	30·08	30·27
Cupric oxide	62·72	62·62

The arsenic was weighed as $2MgNH_4AsO_4 . H_2O$. On further examination of this salt it was found to contain a minute trace of the corresponding phosphate.

---

[1] "On the Constitution of the Native Phosphates of Aluminium." *Proc. R. Irish Academy*. Ser. II., Vol. III., pp. 551-562 (1882).

[2] It would be convenient if different founts of type (black letter italic, for example) could be employed to discriminate molecules of H_2O held with different degrees of tenacity.

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4. Tyrolite.

In a paper published in 1873 (*Chem. Soc. J.* XXVII., 108) I gave the results of some analyses of tyrolite. The specimen examined was conjectured to have come from Libethen, but recent study of its matrix leads me to assign it to Falkenstein. In the above paper tyrolite was stated to contain "calcium carbonate as an essential ingredient not as an accidental impurity." This position, confirmed as it is by the results of three analysts working independently, is not accepted by Professor E. S. Dana (*Mineralogy*, 6th ed., p. 839), whose opinion is obviously influenced by the results of several recent analyses of a mineral from the Mammoth Mine in the Tintic District of Utah. After a careful comparison of the Utah and Falkenstein minerals, I am bound to confess that they appear to belong to the same species. About the same proportion of lime occurs in both. May not the absence of carbon dioxide from the former be explicable by means of the theory that it is represented by some other acid constituent? Anyhow, I am now in a position to offer fresh evidence in favour of my original view. Fortunately, I had preserved several grams of the tyrolite with which I had worked in 1872-3.

The following experiment seems to be decisive. A portion of the mineral, carefully selected, was ground to an impalpable powder and suspended in distilled water. A current of carbon dioxide was then passed through the mixture for some hours. The liquid was filtered, then the clear filtrate was tested for calcium with a positive result. But as copper and arsenic pentoxide were also found in the liquid it became necessary to ascertain the *proportion* of calcium to copper present therein. These metals occurred in the ratio of 1 : 5, the precise ratio in which they exist in the original mineral. As it is inconceivable that calcium carbonate and pentabasic cupric arsenate should possess identical solubilities in carbonated water, it is evident that the mineral tyrolite dissolves *as a whole* in that solvent. This conclusion is greatly strengthened by a further observation accidentally made during the course of the above described experiment. About 100 cc. of the clear filtrate, prepared as just mentioned, were left in a beaker for 48 hours. At the end of that time it was noticed that the liquid was no longer clear. There was a film on its surface and numerous shining particles were floating in it. Both film and particles presented the precise greenish-blue colour and satiny aspect of the original tyrolite; neither could be mistaken for the calcium carbonate which would have been precipitated had the carbonated water simply withdrawn that compound from a mineral in which it existed in admix-

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ture. That no carbon dioxide can be found in the Utah mineral, if it be a different species, would have no bearing on these facts. But if the American and the European minerals be really identical the absence from the former of carbon dioxide may be explicable on the theory of substitution. In further confirmation of the view that calcium carbonate does not exist as an intruding substance in tyrolite, I may state that when the coarsely powdered mineral is dissolving in acid it continues to evolve minute bubbles of carbon dioxide so long as a particle remains.

But if the view I formerly propounded as to the relation subsisting between the calcium carbonate in tyrolite and its other constituents has now been confirmed, yet the formula which I proposed in 1873 for this species needs modification in one particular. For I certainly misinterpreted the meaning of the phenomena which I had then observed as to the loss of water sustained by tyrolite when kept *in vacuo*, or heated to 100 C. Such loss, amounting to 7 or 8 per cent., does *not* represent accidental or hygroscopic water, but corresponds to a definite number of molecules of H_2O. An appearance, which I had observed and had attributed to the presence of interstitial water between the laminæ of the crystals in their central portions, is due to an optical illusion arising from the perfect contact of these portions. So many cases are now known where essential water is lost by minerals, and especially by arsenates and phosphates, when subjected to the influence of dry air or of lowered barometric pressure, that one need feel no surprise at the discovery of another instance of this phenomenon.

In the original paper (*loc. cit.*) to which reference has been made, there occurred an error in the substitution of the symbol for phosphorus for that of arsenic. It may be well, therefore, to reproduce here the figures of the more complete of the two analyses previously published, and at the same time to set down the water found in the mineral in accordance with the view as to its function which must now be held. These are the figures of analysis ii. :—

Tyrolite taken	·4585 gram		
Water lost *in vacuo*	·024	,, = 5·23 per cent.	
Water lost at 100° C. ...	·011	,, = 2·40	,,
Calcium carbonate	·0505	,, =11·01	,,
Cupric oxide	·212	,, =46·24	,,
2 $MgNH_4AsO_4$, H_2O	·205	,, =27·07	,, As_2O_5
Water retained at 100°, by difference ...	...	8·05	,,

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Here is the comparison between these experimental percentages and those demanded by the expression—5 CuO. As_2O_5. $CaCO_3$. 8 H_2O

	Experiment	Theory
CuO	46·24	45·55
As_2O_5	27·07	26·42
$CaCO_3$	11·01	11·49
H_2O	15·68	16·54

As the loss of water suffered by tyrolite *in vacuo* and at 100° C. is half of its total content, the formula of the species may be written :—

$$\left.\begin{matrix} Cu_3As_2O_8.\ 2H_2O \\ CaCO_3 \\ 2Cu(OH)_2 \end{matrix}\right\} 4H_2O$$

The slight deficiency in the experimental percentage of water which corresponds to the $4H_2O$ in the above formula is probably attributable to the imperfect methods of desiccation adopted ; for in many similar cases it is observable that a really good vacuum and the actual temperature of 100° C. (and not the heat attained in the water-oven) are required in order to secure the complete expulsion of the loosely-attached molecules of water.

5. Pharmacolite.

An incomplete analysis of well-crystallised pharmacolite furnishes another example of a perfectly definite mineral species which loses much constitutional water at the ordinary temperature *in vacuo*. The following figures represent the analytical results with the corresponding percentages :—

Pharmacolite taken	·962 gram	
Water lost *in vacuo* at 16° C.	·1155 gram = 12·87 per ct.	after deduction of silica, &c.
Water lost between 100° & 200°	·029 ,, = 8·11 ,,	
Silica and insoluble matter	·028 ,,	

The composition of pharmacolite is usually represented by the formula 2CaO. H_2O. As_2O_5. 5aq. From the desiccation experiments above recorded it would seem that $3H_2O$ are lost *in vacuo*, and $1H_2O$ at temperatures up to 200°. For $3H_2O$ are equal to a percentage of 12·0, while $1H_2O$ corresponds to 4·0 per cent., while experiment gave, respectively, 12·87 and 8·11, or a total of 15·48 per cent. against the 16 per cent. re-

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quired by theory for $4H_2O$. If these conclusions be correct we shall have these expressions for

Pharmacolite in normal state	...	...	$2CaO.\ H_2O.\ As_2O_5.\ 5aq.$
Pharmacolite dried *in vacuo* at 16°	...	...	$2CaO.\ H_2O.\ As_2O_5.\ 2aq.$
Pharmacolite dried at 200°	...	...	$2CaO.\ H_2O.\ As_2O_5.\ 1aq.$

Rammelsberg[1] has pointed out that the second of these formulæ represents the species haidingerite, but his remark seems to be based on the observations of Petersen, who found that pharmacolite suffered a loss of 11 to 12 per cent. of water on being heated to 100° C. That such loss occurs by reduction of pressure only, without having recourse to increase of temperature, does not appear to have been hitherto recorded.

It should be noted that in the new (1892) edition of Dana's *Mineralogy* pharmacolite is assumed to contain one molecule less of water than is assigned to this species in the present note. All the results obtained in the analysis of the native compound confirm the view here adopted.

It may be mentioned here that a specimen of pharmacolite which presented the more transparent aspect of haidingerite furnished me with analytical results confirming those just given as regards the water in this species. In this case the lime and the arsenic pentoxide were also determined, the percentage of the former constituent being 25·04, of the latter 47·95. This latter percentage is indeed about 8 units lower than that demanded by theory, but it is still less in accord with the number (53·3) required by a formula having $5H_2O$ instead of $6H_2O$.

6. Cacoxenite.

Having sacrificed a very fine specimen of this mineral, from Hrbek, near St. Benigna, in Bohemia, I obtained sufficient material for analysis. The deep gold-coloured acicular crystals were separated as far as possible by mechanical means from the traces of impurities which had been detached from the matrix. In dissolving the selected material in dilute hydrochloric acid, the process of solution was not urged forward to its extreme limit. In calculating the percentages given below, the matter which was not dissolved by the acid, and the trace of silica subsequently separated, together amounting to 6·15 per cent., were previously deducted. Much water was lost by the mineral *in vacuo* over oil of vitriol, but none in the air-bath at 100° C.

[1] *Mineral-Chemie*. 2te Auflage, p. 339.

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	Experiment	Theory
Water lost *in vacuo* over H_2SO_4 ...	18·69 ...	18·45
Water (with trace of F) lost on ignition ...	13·11 ...	12·92
Ferric oxide	48·57 ...	49·22
Phosphorus pentoxide	19·76 ...	19·41

These figures correspond with the formula

$$9Fe_2O_3.\ 4P_2O_5.\ 51H_2O,$$

which demands the percentages placed by the side of the experimental numbers. In these theoretical percentages I have divided the 51 molecules of water into two groups, one consisting of 30 molecules and the other of 21 ; it will be observed that the percentage of water lost *in vacuo* corresponds very closely with that demanded by the escape of $30H_2O$. This observation is consistent with such a formula as the following :—

$$\left.\begin{matrix} 4\ (Fe_2O_3.\ P_2O_5.\ 4H_2O) \\ 5\ (Fe_2O_3.\ H_2O) \end{matrix}\right\} 30H_2O$$

This expression is doubtless somewhat complex, and I am not prepared to maintain that the substance analysed was perfectly homogeneous. The results of the analysis might be said to represent a mixture of about one molecule of limnite ($Fe_2O_3.\ 3H_2O$) or of xanthosiderite ($Fe_2O_3.\ 2H_2O$) with four molecules of a basic ferric phosphate having the comparatively simple formula :—

$$\left.\begin{matrix} Fe_2O_3.\ P_2O_5.\ 3H_2O \\ Fe_2O_3.\ 2H_2O \end{matrix}\right\} 7H_2O$$

It will, however, be seen on comparing the percentages demanded by this last formula with those obtained in the analysis of cacoxenite, that they agree fairly well even if we make no allowance for the supposed presence of an excess of some ferric hydrate such as xanthosiderite. Here are the percentages in question :—

			Theory		Experiment
			$Fe_2O_3.\ P_2O_5.\ 3H_2O$ / $Fe_2O_3.\ 2H_2O$ } $7H_2O$		
$2Fe_2O_3$	...	320	... 47·20	...	48·57
P_2O_5	...	142	... 20·94	...	19·76
$5H_2O$	...	90	... 13·28	...	13·11[1]
$7H_2O$	...	126	... 18·58	...	18·69[2]
			100·00		

[1] lost *in vacuo*. [2] lost on ignition.

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I am inclined to think that the above formula may be accepted as that of cacoxenite. It is in fair agreement with the analytical results obtained by v. Hauer in one of his analyses of the Hrbek mineral: a higher percentage of P_2O_5 and less Fe_2O_3 are shown in the two other analyses cited by Dana. But to whatever conclusions further work on cacoxenite may lead, the experiments now placed on record prove, for the first time, that $\frac{7}{12}$ths of the water present in this mineral are retained with far less tenacity than the remaining $\frac{5}{12}$ths.

8. Kühnite.

In the year 1876 I acquired a specimen of a honey-yellow mineral labelled "Chondrarsenite, Långban, Sweden." Quantitative analysis showed that the substance differed from chondrarsenite in containing far less manganese but much more lime and magnesia than that species, and that its blow-pipe reactions were not the same. In fact it bore a very close resemblance to another arsenate of lime, magnesia, and manganese, which was analysed by Kühn (*Liebig Annal.*, XXXIV., 211, 1840), and named by him *Berzeliite*. It occurred in irregular crystalline masses imbedded in a granular limestone and accompanied by hausmannite. It lost nothing *in vacuo* or at 100° (in one experiment the loss on 1·0928 gram was ·0004 gram), but gave a small amount of residue insoluble in acid (·0025 gram from ·3874 gram of mineral; ·002 from ·294; ·001 from ·226; and ·002 from ·3245). The following figures represent the analytical results with the corresponding percentages, the insoluble matter having been in all cases deducted:—

I.	Mineral taken ...	·3849 gram			
	$2\,MgNH_4AsO_4, H_2O$	·358 ,,	=56·29	per cent.	As_2O_5
II.	Mineral taken ...	·292 ,,			
	$2\,MgNH_4AsO_4, H_2O$	·2758 ,,	=56·21	,,	As_2O_5
	$CaCO_3$	·1115 ,,	=21·38	,,	CaO
III.	Mineral taken ...	·225 ,,			
	Mn_3O_4	·008 ,,	= 3·52	,,	MnO
	$CaCO_3$	·0905 ,,	=22·52	,,	CaO
	$Mg_2P_2O_7$	·079 ,,	=12·65	,,	MgO
IV.	Mineral taken ...	·3225 ,,			
	Mn_3O_4	·0105 ,,	= 3·04	,,	MnO
	$CaCO_3$	·1205 ,,	=20·92	,,	CaO
	$Mg_2P_2O_7$	·1195 ,,	=18·35	,,	MgO

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The mean percentages are :—

CaO	...	...	21·61
MgO	....	...	13·00
MnO	...	...	8·28
As_2O_5	...	...	56·25
Deficiency		...	5·86
			100·00

The questions naturally arise "what constituent of the mineral has been missed?" and "was water present?" Kühn had indeed noticed a loss on ignition of his mineral, equal in one case to 0·3 per cent.; in another to 2·95 per cent.; but he did not prove such loss to arise from the escape of water. In order to determine the point I heated to very low redness a most carefully selected sample of the mineral, and found that the loss on 1·539 gram amounted to 0·004 gram only, or 0·26 per cent. —a negligible quantity. The species is obviously anhydrous. But an explanation of the analytical deficit was soon discovered. On dissolving the finely powdered mineral in dilute hydrochloric acid a brisk evolution of a gas which proved to be carbon dioxide was observed. No selection, however careful, of the fragments of the crushed mineral could eliminate the substance giving rise to this effervescence, and I am forced to conclude that the embedded nodules of Kühnite are interpenetrated with the calcareous matrix in which they occur. If this conclusion be just, we may look upon the substance analysed as an intimate mixture of true kühnite with about 7 per cent. of calcite, kühnite itself being represented by the formula $(CaMgMn)_3As_2O_8$. The analytical results correspond fairly well with the expanded formula $-4{\cdot}5CaO.\ 4MgO.\ 0{\cdot}5MnO.\ 3As_2O_5$, although nearly 2 per cent. of the constituents of the mineral remain still unaccounted for.

Thus far had I written, in recording the results obtained by me in 1876, when I observed, on referring to the 1892 edition of Dana's *Mineralogy*, that some work has been done during recent years towards clearing away the obscurity in which the constitution of kühnite was involved. In the variety known as pyrrhoarsenite carbon dioxide has been found to the extent of between 1 and 2 per cent. This result confirms the observation already recorded in the present note, and is probably to be explained in the same way. As ordinary kühnite is isometric, I asked Mr.

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Miers to examine optically some fragments of the specimen which I had analysed. He tells me that the appearance of the mineral in polarised light is in accord with my view that it consists of an isometric compound interpenetrated with small particles of calcite. It seems, however, t at a doubly-refracting arsenate, having the same composition as kühnite, also exists. It is the pseudoberzeliite of W. Lindgren, and also the similar mineral from the Moss Mine, Nordmark, described by Igelström (Dana, *Min.*, 6th ed., p. 758).

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A Basic Ferric Sulphate, from Parys Mount, Anglesey.

By A. H. Church, F.R.S.

[Read November 20th, 1894.]

AN orange-coloured ochreous substance from Parys Mount, Anglesey, was recently submitted to analysis. It gave the following percentages :—

		Silica deducted.
Water lost at 100° C	13·51	
Water lost on moderate ignition ...	12·85	26·94
Sulphur trioxide	13·44	.. 13·74
Ferric oxide	57·85	... 59·12
Silica	2·14	
Alumina, Lime, &c. (by difference) ...	·21	
	100·00	

The formula $2Fe_2O_3 . SO_3 . 8H_2O$ requires these percentages :—

Water	26·47
Ferric oxide	58·83
Sulphur trioxide ...	14·70

The observed loss of water at 100° corresponds to $4H_2O$, which requires 13·24 per cent. If we assume that the molecular weight of this sulphate is thrice that represented by the empirical formula above given, we shall arrive at the expression for a hexabasic compound :—

$$Fe_2O_3 . 3SO_3 . 5Fe_2O . 24H_2O.$$

This corresponds to the body described by Berzelius as gradually produced, in the form of a yellow precipitate, by exposing a solution of green vitriol to the air. More recently O. Meister has described (*Deutsch. Chem. Gesell.* 1875, p. 771) a similar body to which he assigned the formula $2Fe_2O_3, SO_3, 7H_2O$. He obtained this salt by washing with cold water a crystallised and less basic sulphate—$Fe_2O_3 . 2SO_3 . 15H_2O$. As the

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mineral now under discussion loses half its water at 100°, it may, after drying at that temperature, be represented by the formula—

$$Fe_2O_3.\ 3SO_3.\ 5Fe_2O_3.\ 12H_2O.$$

The mineral, in its natural condition, corresponds to a compound of one molecule of normal ferric sulphate, or *coquimbite*, with 5 molecules of normal ferric hydrate :—

$$\left.\begin{matrix} Fe_2O_3.\ 3SO_3.\ 9H_2O \\ 5\ (Fe_2O_3.\ 3H_2O) \end{matrix}\right\}$$

After drying at 100° it may become :—

$$\left.\begin{matrix} Fe_2O_3.\ 3SO_3.7H_2O \\ 5\ (Fe_2O_3.\ H_2O) \end{matrix}\right\}$$

But the physical properties of our mineral are not those which would be expected in a compound such as that which we have imagined, and it therefore seems better to take the simplest possible formula for it, and to regard the mineral as a single chemical entity :—

$$Fe'''_4 \left\{ \begin{matrix} O_5 \\ SO_4 \\ (OH)_4 \end{matrix} \right\} 4\ aq$$
$$H_4$$

In this case the 4 aq. outside the compound proper represent the water lost at 100°. The *glockerite* of Naumann may be written in the same manner, but with 2 aq. instead of 4 aq.

This mineral, in the lump or in powder, appears of a deep yellow and is quite opaque to the unassisted eye. But when viewed in the microscope with a sufficient magnifying power, the individual particles of which it consists are seen to be transparent, or at least translucent, and crystalline. In polarised light they seem to be isometric.

Although the result of the action of atmospheric oxygen and of water upon ferrous sulphate, it is doubtful whether the product described in the present note can be fairly regarded as entirely natural. Possibly the ferrous sulphate from which it has been derived may have been formed, not directly from iron pyrites, but from scrap iron reacting upon the copper sulphate occurring in the waste waters of a mine. However, there can be no doubt that the ferric sulphate above described frequently occurs as a wholly natural product.

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Occurrence of Mispickel in the Stewartry of Kirkcudbright.

By P. Dudgeon, F.R.S.E.

[Read June 19th, 1894.]

HAVING heard that a vein of what was supposed to be mispickel had been found about 6 miles north of Newton Stewart, in company with Professor Heddle I visited the place a week or two since. We found the vein had been opened in two places and some of the mineral had been taken out. It proved to be mispickel. The vein runs pretty nearly north and south: it occurs at the junction of the granite and silurian rocks, commencing about half-a-mile south of the Murray monument, crossing the Palnure Burn, running nearly due south for more than a mile, and then heading to the eastward, where, at about three-quarters of a mile further on, another opening has been made in which is found chalcopyrite associated with mispickel. The vein, where it has been opened close to the Palnure Burn, is about 7 inches wide, and contains only mispickel. The interest to be attached to this discovery is that mispickel is an exceedingly rare mineral in Scotland, in fact only one rather doubtful locality is mentioned in mineralogical works.

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Augelite.

By G. T. Prior, M.A., F.G.S., and L. J. Spencer, B.A., F.G.S.

[Read November 20th, 1894.]

AUGELITE was one of several aluminium phosphates from the iron mine of Westanå, Skåne, Sweden, described by C. W. Blomstrand in 1868 (*Öfv. Ak. Förh. Stockh.* XXV. 1868, p. 199). He states it to be a massive mineral with distinct cleavages in three directions, and names it augelite ($\alpha\upsilon\gamma\eta$ lustre) on account of the strong pearly lustre on the cleavage surfaces. He determines its specific gravity as 2·77, and, as the result of his analyses, represents its chemical composition by the formula, $2Al_2O_3.\ P_2O_5.\ 3H_2O$. Since this paper of Blomstrand, as far as we are aware, no further reference to augelite has been made, and, since hitherto distinct crystals of the mineral have not been found, its position as a definite species seems to have been regarded as somewhat doubtful, for we find that Dana, in the last edition of the *System of Mineralogy*, includes it in a rather unsatisfactory group of more or less doubtful species appended to evansite.

The crystals of augelite which supplied the material for the physical and chemical determinations given in the following paper, were found associated with the bournonite and octahedral pyrites from Machacamarca, Bolivia.[1] Almost all the bournonite specimens from this locality in the British Museum collection showed augelite, either filling cavities in the bournonite, or in isolated crystals upon, and lining crevices in, the quartzose matrix (consisting of angular quartz grains with interspersed iron pyrites) on which the bournonite was deposited. The crystals are of small size, the largest not measuring more than 6·5mm., and the majority not more than 3 to 4mm. along their greatest diameter. The crystallographic measurements were for the most part made on still smaller crystals found embedded in a yellow crumbling decomposition product from the pyrites and bournonite, which coated one side of a large specimen of bournonite.

[1] There seem to be at least three places called Machacamarca in Bolivia, two in Oruro, and one in Potosi.

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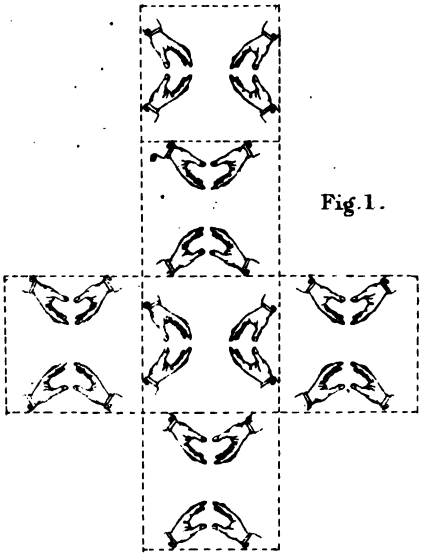

Fig. 1.

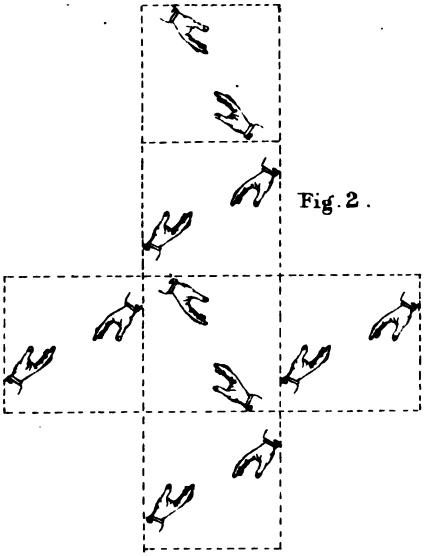

Fig. 2.

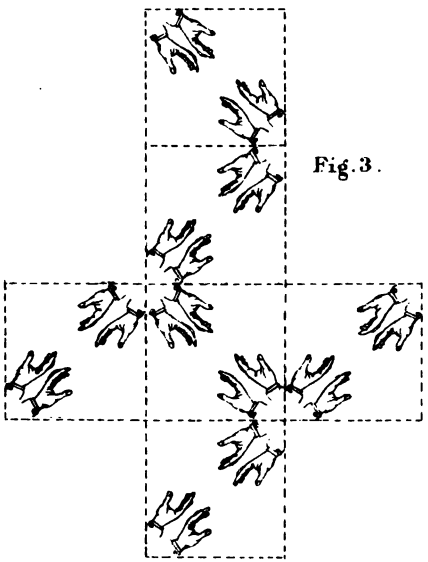

Fig. 3.

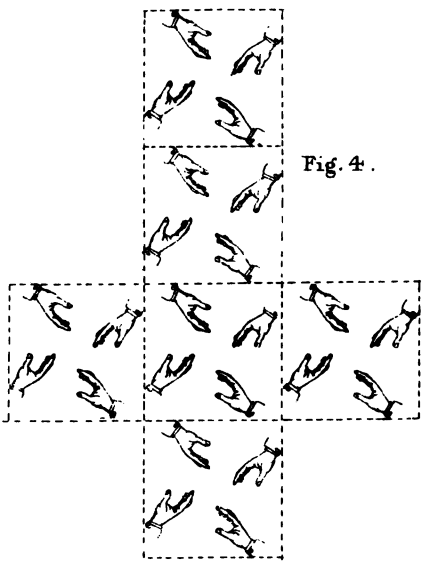

Fig. 4.

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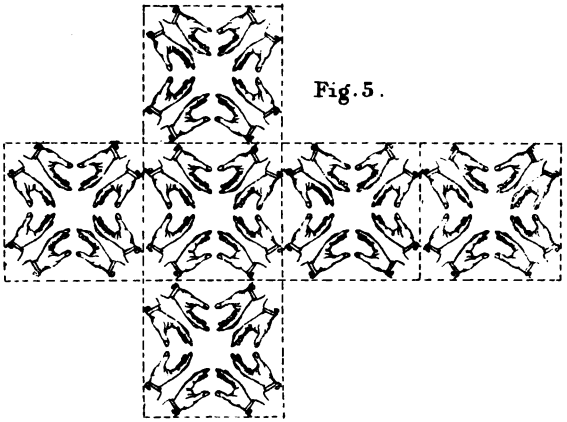

Fig. 5.

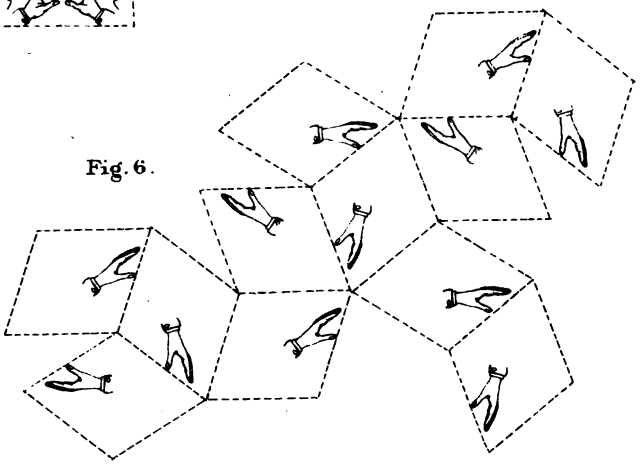

Fig. 6.

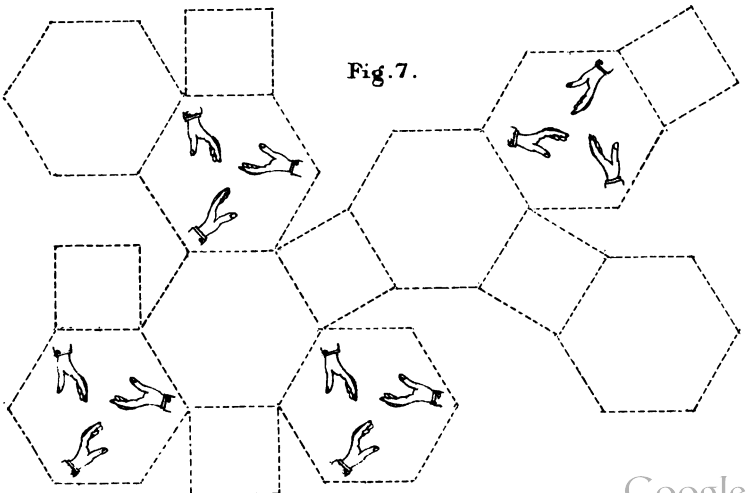

Fig. 7.

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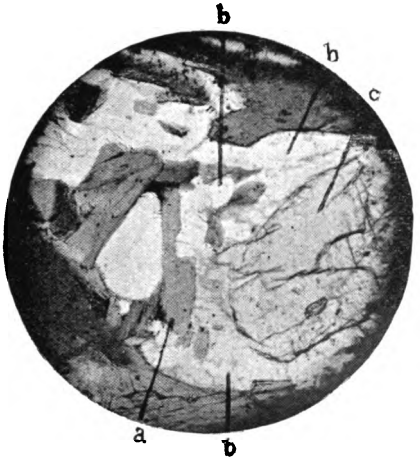

FIG. 1.—Cordierite, corroding biotite and cyanite.

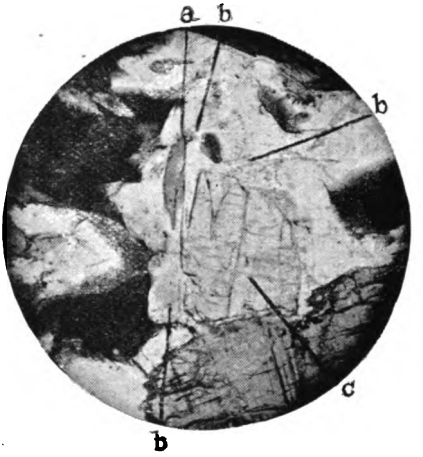

FIG 2.—Cordierite, corroding biotite and cyanite.

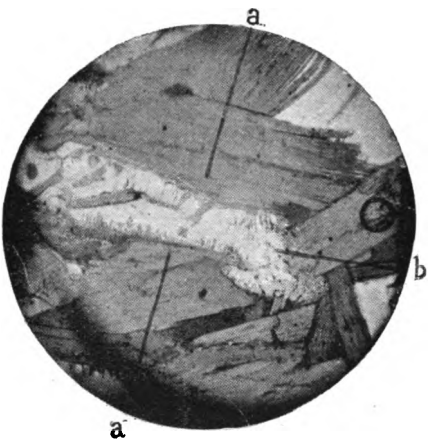

FIG. 3.—Cordierite intrusive in biotite.

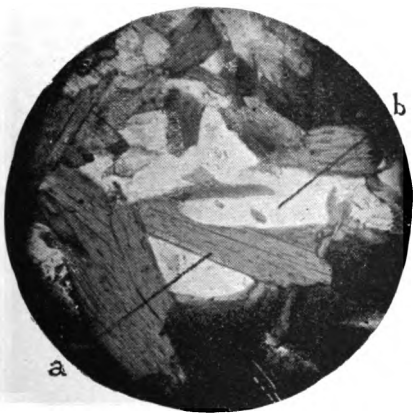

FIG. 4.—Cordierite corroding and cutting obliquely across laminæ of biotite.

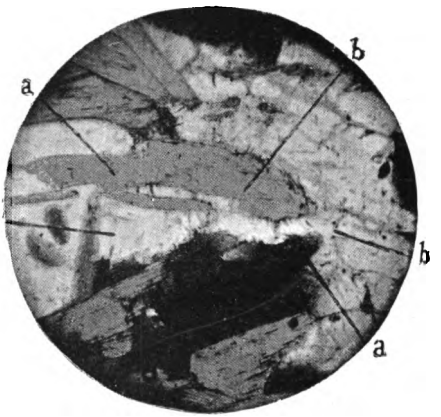

FIG. 5.—Cordierite, corroding and intruding into biotite.

(*a*) Biotite. (*b*) Cordierite. (*c*) Cyanite.

Between (*a*) (*a*) of figs. 3 and 5, fringes of biotite tags can be seen along the edges of the biotite with aid of a lens.

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Crystalline Form.

Monosymmetric. $a : b : c = 1{\cdot}6419 : 1 : 1{\cdot}2708$. $\beta = 67°33\frac{1}{2}'$

$100 : 110 = 56°87'$; $001 : 101 = 28°54\frac{1}{2}'$; $001 : 011 = 49°35\frac{1}{2}'$.

Observed Forms.—*c* (001), *m* (110), *x* ($\bar{1}01$), *f* (101), *a* (100), *b*(010), *n* (112), *r* (011), *o* ($\bar{1}12$).

Doubtful forms—225, 334, 223, 665, 221, 530, 310 in the zones *cm* and *mm*.

Besides these there were other indefinite reflections in the zones *cm*, *mm*, *xm*, *ca*.

	Calculated.	Measured.	Limits.	No. of Observations.
ac	67°33½′	67°34′	67°24′ —67°39′	3
af	38°39′	38°37′	38°31′ —38°43½′	2
cf	28°54½′	28°43′	28°30½′—28°54′	7
cx	45°26½′	45°22′	44°36′ —46° 4½′	24
xm	77°35½′	77°40′	77°29′ —78° 6′	19
cn	31° 7½′	31° 9′	30°41½′—31°19′	9
**mc*	—	77°52½′	77°46′ —77°59′	20
**mm*	—	66°46′	66°28′ —67° 7′	32
**fm*	—	64°33′	64°27′ —64°38′	12
fn	28°26′	28°24½′	28°13′ —28°30½′	2
fr	55°25½′	55°13′	..	1
an	54°53′	54°55′	54°36½′—55° 8½′	4
cr	49°35½′	—	..	..
c : 111	46°42½′	—	..	..
co	39°11½′	39° 9½′	..	2

DOUBTFUL FORMS.

225 : *c*	26°20	26°18′	..	1
334 : *c*	40°11½′	40°24′	39°0′—40°56′	3
665 : *c*	50°37′	50°30′	..	1
221 : *c*	59°57½′	60°	..	1
530 : *m*	14°18′	14°30′	14°—15°	2
310 : *m*	29°47′	29°19′	..	1

The basal plane is usually represented by one or more *vicinal faces* which lie in the zones *cx* and *cm*, and are generally the brightest faces, giving the best images. On account of these vicinal faces, the measurements from the prism plane varied from 77° 19½′ to 79° 31′ (number of observations 87). Within these limits they fell into five fairly well marked groups of which the means were 77° 29′, 77° 45′, 77° 52½′, 78° 2′, 78° 24′. The third of these measurements (77° 52½′) was taken as the true angle *cm*, for the calculated angles between other faces were found to be in closer agreement with the measured angles when this value, instead of any of the other four, was given to *cm*. The first two measurements

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will then be due to vicinal faces in the zone *cm* at $7\frac{1}{2}'$ and $23\frac{1}{2}'$ from *c*, and the last two to vicinal faces in the zone *cx* at $18\frac{1}{4}'$ and $1° 0\frac{1}{2}'$ from *c* (towards *x*).

Characters of the faces :—

c. Smooth to deeply striated parallel to its intersections with *x* and *m*; the vicinal faces in the zone *cx* are striated parallel to their intersections with *x*, and those in the zone *cm* to their intersections with *m*. The basal plane is often represented by only one of the vicinal faces, which is very smooth and bright, giving a single sharp image.

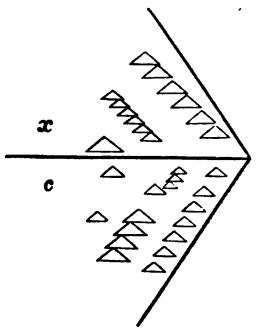

FIG. 1.

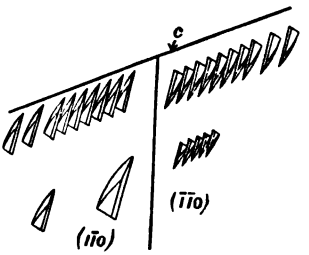

FIG. 2.

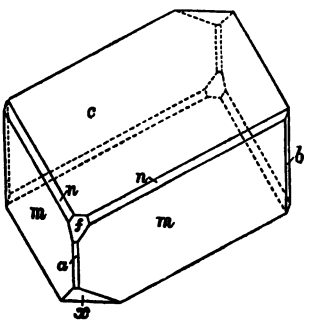

FIG. 3.

x. Usually rough and pitted; striated parallel to its intersections with *c* and *m*; rarely smooth.

m. Smooth and bright; striated parallel to the prism edges, and sometimes very faintly parallel to its intersection with *c*.

f. Small and bright.

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n. Small narrow plane, which, with several indistinct planes (see list of doubtful forms above), truncates the edge *cm*.

Habits:—

(1.) The most common habit is tabular parallel to *c* (Fig. 3), with only the forms *c* and *m* prominent. The isolated crystals on the quartzose matrix usually assume this habit.

(2.) Thin triangular plates tabular parallel to *m*, with the edges bounded by *c*, *x*, and *m*.

(3.) Prismatic, with *c* and *x* equally developed, closely simulating rhombic crystals since the angles *cm* and *xm* are so nearly equal.

The crystals found embedded in the yellow decomposition product were of the two last habits.

Etching:—

Many of the crystals, especially those from the decomposition product, showed well marked etch-figures, and similar figures could be easily produced by heating crystals for a short time in hydrochloric acid. In Fig. 1 are shown the etchings on the *c* and *x* planes, and in Fig. 2 those on the prism planes. In their form they accord with the oblique symmetry of the crystals. As seen in the figure, they are generally arranged in lines parallel or nearly parallel to one, and one only, of the prism edges. This would seem to suggest a hemimorphic development of the crystals, and this idea receives some slight support from the fact that on one crystal the striations observed on the *x* plane were again only parallel to one of the prism edges. Hemimorphism was also suggested by the development of the form *n* on one or two crystals. No pyroelectricity on change of temperature, however, could be detected by means of Kundt's method.

Physical Characters:—

Colourless to white; transparent to translucent; streak white; lustre vitreous, inclining to pearly on the cleavage surfaces. Cleavage: *m* perfect; *x* less perfect, but good. Fracture uneven.

Hardness 4·5 to 5: brittle.

Density (weight of 1cc.) 2·696 at 22°C; material used 0·4166 gr.

Under the microscope, in some of the crystals, liquid cavities with bubbles were observed. No effect seemed to be produced on the bubbles on heating the crystals up to 54°C, so that the liquid was most probably water or an aqueous solution, and not carbonic acid.

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Determination of the Optical Constants :—

The double refraction is positive. The plane of the optic axes is perpendicular to the plane of symmetry. The acute bisectrix makes with the vertical axis c' an angle of 34° approx. (in the acute angle β), *i.e.* it makes an angle of $11\frac{1}{2}$° with the normal to c and an angle of 56° with the normal to a.

The angle of extinction on m measures 25° to the prism edge.

Optical axial angle (sodium light) :—

$$2E_a = 84°42'. \quad 2H_a = 51°29'. \quad 2H_o = 132°12'.$$

From which $2V = 50°49'$.

These determinations were made with plates cut at right angles to the 1st and 2nd mean lines. The oil used was oil of anise ($n = 1{\cdot}5569$ as determined by means of the total reflectometer). No dispersion of the axes was observed.

Refractive Indices (sodium light) :—

$$\alpha = 1{\cdot}5736, \ \beta = 1{\cdot}5759, \ \gamma = 1{\cdot}5877.$$

Double refraction, $\gamma - \alpha = {\cdot}0141$.

α and γ were determined by means of a prism cut symmetrically about the plane of symmetry, and with the refracting edge parallel to the acute bisectrix. β was determined by calculation from the optic axial angles in oil in the two plates, and the index of refraction of the oil.

The value of $2V$ calculated from the above values of α, β, γ, is 47°56′.

Measurements of the indices of refraction through the natural prism (m) gave the two values 1·5745 and 1·5889.

Owing to the small size of the transparent crystals, and the consequent difficulty in grinding down the plates and prisms by hand, the errors of orientation amounted in some cases to three or four degrees.

Experiment showed that the variation of the optical axial angle on change of temperature was scarcely appreciable. For a rise in temperature of 100° there appeared to be only a slight decrease in the angle of less than half a degree.

Chemical Characters :—

The mineral is infusible, and becomes opaque before the blowpipe. With cobalt nitrate it gives a blue colour. It yields much water in the closed tube. In fine powder it is slowly dissolved on digestion in hot concentrated hydrochloric acid.

Material for the quantitative analyses was carefully picked out under

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the lens, and then separated as far as possible from quartz by means of methylene iodide. After the separation with methylene iodide the material was a second time picked out under the lens. It was found, however, to be impossible to completely remove the quartz from the augelite, for the very carefully selected material used in analysis I was found to contain 1·81 per cent. of silica, while the less carefully picked material used in the preliminary analysis II contained as much as 13·6 per cent. Blomstrand speaks of the difficulty of separating the quartz, and obtained in his analyses from 4 to 13 per cent. of silica. In the preliminary analysis II the water was determined by ignition, the phosphoric acid was separated by molybdate solution and reprecipitated by magnesia mixture, and the alumina was precipitated by ammonia and ammonium sulphide in the filtrate from the molybdate precipitate.

In analysis I the water was determined directly by absorption in a calcium chloride tube. A plug of sodium carbonate was placed in the mouth of the combustion tube in which the mineral was heated, to absorb any hydrofluoric acid which might be given off; but, on testing the sodium carbonate after the experiment, no fluorine was detected, and the increase in weight of the calcium chloride tube corresponded fairly closely with the loss in weight of the material. In this analysis the mineral was dissolved in hydrochloric acid, and the solution was divided into two portions, in one of which the alumina and the phosphoric acid were precipitated together by ammonia, while in the other the phosphoric acid was precipitated by molybdate solution, and finally weighed as pyrophosphate of magnesium.

The alumina was carefully tested for beryllium, but with negative results.

Result of Analyses:—

	I.	II.	III. (Blomstrand)	IV. (Theory)
P_2O_5	34·60	35·33	35·04	35·50
Al_2O_3	51·40	50·28	49·15	51·00
CaO	0·11[1]	0·90[1]	1·09	—
H_2O	13·77	13·93	12·85	13·50
Fe_2O_3	—	—	0·89	—
MnO	—	—	0·31	—
	99·88	100·44	99·33	100·00

[1] Most probably partly, if not wholly, derived from the reagents or from their action on the glass and porcelain vessels used in the analyses.

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Weight of material used in analysis I = 0·8379 gr.
,, ,, in analysis II = 0·3164 gr.

No water was given off below 360°.

Under III is given the mean of Blomstrand's four analyses of the mineral from Westanå, and under IV the theoretical numbers required by the formula $2Al_2O_3 . P_2O_5 . 3H_2O$, or $AlPO_4 . Al(OH)_3$.

The orthorhombic dufrenite has the analogous formula—

$$2Fe_2O_3 . P_2O_5 . 3H_2O.$$

The result of the analyses of the mineral from Machacamarca, together with the determination of the specific gravity and the observation of the three cleavage surfaces, showed that augelite was the only mineral to which it could be referred. Any doubt as to the absolute identity of the mineral from Bolivia with that from Sweden was at once set at rest when, through the kindness of Prof. Blomstrand, the Museum became possessed of a small specimen of the original augelite from Westanå; for the angles between the three cleavage surfaces were found by measurement to be, within a few minutes (mm = 66°52′, mx = 77°33′), the same as those between the corresponding faces on our crystals, and prism cleavage flakes from both minerals showed under the microscope with a $\frac{1}{12}$ immersion the same optical character, viz. the emergence of an optic axis just beyond the edge of the field.

Judging from the Museum specimens, augelite appears to be by no means a rare mineral at Machacamarca. That it has been so long overlooked may perhaps be accounted for by its having been mistaken for other minerals. Thus Sandberger (*Neues Jahrb.*, 1886, (1), p. 89) speaks of bournonite from this locality associated with barytes. We have found no barytes on any of the bournonite specimens from Machacamarca in the Museum collection, and it is just possible that the barytes to which Sandberger refers was really augelite, for the habit of the two minerals is somewhat similar.

Besides the augelite, on specimens from Machacamarca in the Museum collection we have noted the following minerals:—

Bournonite.—Grooved prisms with the forms *a b m c e n o u y* Ω[1]. The faces in the zone *n o u* [11$\bar{1}$] are sometimes large. The crystals are usually bright, but sometimes coated with melaconite, and at times much altered.

[1] The letters are those used in Dana's Mineralogy.

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Iron Pyrites.—Symmetrically developed octahedra, usually very bright, but sometimes with a thin, dull, black coating (melaconite ?). One large isolated crystal is an icositetrahedron β {322} with small {111} planes. Another crystal shows the forms n {211} and p {221} besides the large octahedral faces.

Zinkenite.—Interlacing acicular crystals on the bournonite. A few needles are sometimes enclosed in the augelite. Sandberger (*loc. cit.*) notes the occurrence of guejarite on bournonite from Machacamarca. We have been unable to detect this rare mineral on our specimens : the acicular crystals on the bournonite on analysis always proved to be zinkenite.

Zinkenite, bournonite, pyrites, argentiferous galena, and tetrahedrite are mentioned by Damour[1] as occurring at Machacamarca.

Mispickel.—A few minute prisms on the pyrites, terminated by a very low pyramid and brachydome approximating to the basal plane.

Quartz.—Minute crystals covering the surface of the quartzose matrix on which the bournonite occurs.

Chalcedony.—Stained with oxide of iron.

Bleinierite.—Pseudomorphous after zinkenite.

Chalcanthite.—In the decomposition product from the bournonite.

Melaconite.—Thin dusty layer on the bournonite.

Anglesite.—In thin flakes, coating the bournonite crystals and lining crevices in them.

Blende.—Very rough, irregular, black crystals.

Copper Pyrites.—Massive.

We have given the above brief account of the mineral occurrences at Machacamarca since there appear to be very few references to the subject. Dana (*Mineralogy*, 6th Ed., p. 128) mentions Machacamarca as a locality for bournonite, and Domeyko (*Mineralojia*, 3rd Ed., p. 235) gives an analysis and short description of the mineral from this locality; but these, together with the two quoted above, are the only references we have been able to find respecting minerals from Machacamarca.

[1] F. de Castlenau, *Expédition dans les parties centrales de l'Amérique du Sud*, 1850–1. Vol. v. pp. 438–440.

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A Note on Cone-in-Cone Structure.

By Professor T. G. Bonney, D.Sc., LL.D., F.R.S., &c.

[Read November 20th, 1894.]

THE structure called cone-in-cone attracted my attention when I was working at certain forms of jointing and spherulitic structures in rocks,[1] and has been studied in a desultory fashion ever since. Moreover, the Museum of University College possesses some good specimens of cone-in-cone obtained by the late Prof. Morris, and I received a present of others, which had been used by Mr. W. S. Gresley for his suggestive paper[2] when he left England for America. But though I formed some general conclusions on the subject, I abstained from writing, because I felt doubt concerning one point of importance, and had never seen a good example of cone-in-cone in the field. Both these obstacles were removed in the summer of 1892, so I venture to add a few words to the valuable paper of my friend, Prof. G. A. J. Cole,[3] not by way of criticism, but of confirmation and supplement. My conclusion, arrived at independently, is practically identical with his, and with that originally advocated by Dr. H. C. Sorby,[4] viz. that the structure is primarily and essentially due to crystallisation, which has started from a number of independent centres, either on or near to one surface of the bed, and has proceeded inwards, as spherulites attempted to form themselves, but produced sheaf-like growths from being crowded together. A similar process occurs, as I have already[5] described, in the devitrification of glass.

[1] *Quart. Jour. Geol. Soc.*, XXXII. (1876), p. 140. *Geol. Mag.*, 1877, p. 499.

[2] *Geol. Mag.*, 1887, p. 17. A very interesting paper by the same author appeared in the *Quart. Jour. Geol. Soc.* for Nov. 1894, p. 731, after this note had been sent to the Secretary of the Mineralogical Society. It brings forward additional evidence in support of the "crystallisation" theory, and practically anticipates some part of my note. But I leave it as written, since the conclusions were formed independently.

[3] *Min. Mag.* X. p. 136.

[4] *Brit. Assoc. Rep.*, 1859, pt. 2, p. 124.

[5] Presidential Address to the Geological Society, 1885. *Quart. Jour.* XLI. *Proc.* p. 95.

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It is beautifully illustrated in a specimen which I obtained in 1892 from the upper part of the Wealden group in Sandown Bay, Isle of Wight. It formed part of the top "beef" bed (*f* of Prof. Judd's section[1]). This bed, above an inch in thickness, overlies a limestone "crowded with Cyrena and a few oysters." A slice cut so as to exhibit the upper bed and part of the lower shows the latter to be a somewhat "dirty" limestone containing numerous fragments of bivalves (probably for the most part *Cyrena*), with some of gasteropods (? *Paludina*), many valves of *Cyprides*, single and double, and mineral grains, chiefly quartz, the last being more plentiful in some bands than in others. From the top of this bed the crystalline "brushes" diverge upwards (the mineral being generally calcite, but perhaps sometimes ankerite[2]). The organic fragments, such as the convex sides of *Cyrenæ* and rather notably of *Cypris* valves, with occasionally (I think) a mineral grain, serve as *points d'appui* for the apices of these cones of diverging crystallites. When any two come together the line of junction is clearly indicated, especially when the nicols are crossed, and the structure of each sheaf of crystallites is rendered more conspicuous, but sometimes this line is made yet more distinct by a thin film of dark mud, probably extruded, as Prof. Cole suggests, during crystallisation. Fine lines, apparently cleavage planes, may be seen making angles of from 20° to 30° with the axis of the crystallites, and pointing downwards. Similar lines, pointing in the opposite direction, may be occasionally noticed. In the lower band the crystallites in the interior of the *Cypris* cases not unfrequently exhibit a radial structure, to which Dr. Sorby has already called attention. It may be noted also that the prismatic layers in the molluscan fragments are replaced, partially or often wholly, by granular calcite, but the nacreous layers are less affected. Probably the former were originally aragonite. This remarkably interesting and beautiful example confirms the evidence afforded by other specimens in my possession, similar to those described by Prof. Cole, and convinces me that he is right in attributing the cone-in-cone structure primarily to crystallisation.

But we have also to account for the peculiar conical fracture which gives the name, and the fact that the surfaces of the cones are sometimes covered with approximately horizontal striations. The former may be thus explained. A half-spherulite may be regarded as consisting of acicular crystallites diverging from a centre and arranged symmetrically

[1] *Quart. Jour. Geol. Soc.* XXVII. (1871), p. 220.

[2] In the specimens from the Coal Measures which I have examined, the mineral is very often chalybite.

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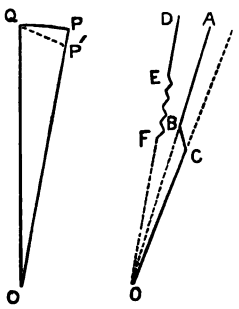
about a common axis, like a series of conical shells with a gradually increasing vertical angle. The rock itself is made up of a series of cones, representing portions of such groups of shells. Suppose it affected by a set of uniform strains due to contraction, such as would be produced in drying: if its material were perfectly uniform, it would break into vertical hexagonal prisms; but inasmuch as it has the structure just described, the surfaces of these cones will be surfaces of weakness (especially if they are parted here and there by films of extruded mud), and will determine the direction of fracture. Thus groups of cones will be developed, each consisting of one or more shells with a common apex and axis, and forming, at the outside of the bed, sets of concentric circular cracks generally two or three in number.

But the surface of rupture sometimes travels towards the axis, so as to produce a spiral crack on the outside. Of this I venture to offer the following explanation. Suppose P Q, two adjacent points in the circular base of one of these cones; let each be attracted towards the point O, its centre (corresponding with the end of the axis), and the conditions be such that fracture takes place at P slightly before it does at Q. On yielding let P move to P′. The effect of this is that Q is now also pulled slightly in the direction of Q P′, and has a tendency to move, not only along the radius O Q, but also slightly in the direction of P′. So the crack passes a little within the circle P Q and takes a spiral course. If the strains caused P to move in the opposite direction, the crack would travel outwards.



In regard to the other structure, the ribbed external surfaces, my view of their cause practically agrees with that put forward by Prof. Cole. I have already spoken of the tendency to form conical shells, and of the cleavage planes which exist in the rhombohedral carbonates (particularly in calcite) composing these masses. These planes also are surfaces of weakness, symmetrically disposed in consequence of the mode of growth of the aggregated crystallites.[2] Thus when a fracture occurs it may occasionally flash outwards, as shown at B C in the line A B C O, or turn in and out, as at E F in the line D E F. Both these forms may be found,

[2] They are indicated in the illustrations to Prof. Cole's paper, Figs. 1-3, pp. 140-141.

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but the first is more usual. Sometimes these ribs are marked by carbonaceous crests or covering films; commonly they are not straight lines, but somewhat arched, with convexities towards the base of the cone. This may be the explanation: the development of the spherulite would probably include times of pause; these would produce surfaces of slight discontinuity in the form of spheres, and along these there would often be extrusion and deposition of carbonaceous material, which would make them more distinctly surfaces of weakness. When the axis of the cone of fracture was longer than a radius of the sphere (which would be, I think, the general tendency), these surfaces, in section, would arch upwards. The explanation, I admit, seems rather far-fetched, but after a good deal of consideration I am unable to devise a better.

Thus the cone-in-cone structure, as Professor Cole states, is primarily due to crystallisation, and is the result of a tendency to form "spherulites," though in a sedimentary instead of in an igneous rock. Its relation to the ordinary micro-columnar structure called "beef" is undoubtedly very close; the latter, indeed, may be regarded from the mathematician's point of view as the limit of the former, when the number of centres of independent crystallisation becomes infinite. But the developments of the cone-in-cone structure, its existence in short *as cone-in-cone*, is due to contraction subsequent to this crystallisation, and thus the mechanical cause is not less essential than the chemical one for its formation.

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On the Occurrence of Delessite in Cantyre.

By Professor Heddle and Mr. Stuart Thomson.

[Read November 20th, 1894.]

DELESSITE is of much rarer occurrence in Scotland than saponite, and moreover it is by no means so characteristic in its appearances.

Its modes of occurrence are much the same, only it is much less frequently the tenant of druses, affecting rather rents or fissures, and in these last it frequently goes to form what may be called a "composite vein." This may be filled for the most part with fibrous calcite, transversely disposed, and the reopening of the fissure is disclosed by the delessite, which, after lining one side of the vein for some distance, suddenly crosses the fibres of the calcite diagonally, and lies between it and the rock upon the opposite side.

Among a series of rocks lately forwarded to me by Mr. Gray, the industrious and observant curator of the admirably arranged little museum at Campbelltown, there was a specimen from Knockscalbert quarry which evidently was either saponite or delessite. The appearance and colour was certainly more that of the latter, but the rarity of that mineral did not leave much room for hope that it was so. The determination of the amount of water having shown that it was not saponite, Mr. Gray was requested to secure if possible a sufficiency for analysis.

This he speedily did, and he also furnished the following notes as to its occurrence.

"It is only found in the very centre of the quarry, a few feet from the bottom, and about 30 feet from the surface, that being the depth of the quarry. At present it shows over an area of about 3 yards. Where it does occur, every bit of rock is completely glazed with it; but the layer of glaze is very thin, as you will see by the hand-specimen which I send."

The physical properties are as follows :—

It has a dark green colour. The thickness of its veins is seldom over half-an-inch—generally it is in mere scales. It is everywhere bright

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from the polish of slickenside movements. The direction of the slickenside striæ shows that even within a space of a few inches the rock fragments must have been moving in every direction. It is softer than the nail, and the colour of its streak is dark sap green. It does not break into fragments in water, nor when suddenly placed in the mouth.

The specific gravity was determined on three fragments ;

On 287·27 grains	=	2·638
On 158·5 ,,		2·578
On 226·2 ,,		2·609
Mean ...		2·608

The analysis yielded :—

	1st		2nd
Silica ...	34·69	...	34·37
Alumina ...	5·48	as $Al_2O_3Fe_2O_3$ 36·49	36·88
Ferric Oxide ...	10·82		
Ferrous Oxide	18·71		
Lime ...	2·49	...	2·16
Magnesia ...	12·21	...	12·00
Water ...	15·19		
	99·59		

7·29 of the water was given off at 100° C.

Although this composition differs considerably from that of other Scotch delessites, as previously determined by one of us, it yet accords fairly well with that of some foreign delessites.

The inclosing rock—a dense dolerite—is so little altered that it is not easy to say which constituent has yielded the mineral, but it appears to have resulted from an alteration of the augite.

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OBITUARY.

Patrick Dudgeon, F.R.S.E.

ON the 9th of February, Mr. Dudgeon, of Cargen, one of the original members, indeed one of the founders of the Mineralogical Society, departed a useful and honoured life at the ripe age of seventy-seven.

A cultivator of several branches of science, he had, with his usual energy, been in the early part of the day tabulating for publication the *Meteorological Record*. In resting thereafter he was called to meet death face to face; and no one could more truly be said to have done so, as he was found in his chair, hands on knees, and looking before him with straightforward gaze.

All the district in his neighbourhood mourns the loss of a typical Scottish gentleman, a kind and considerate landlord, a cultured and honoured citizen. Friends of his own standing mourn features of character which they know can never be replaced to them.

Born in Mid-Lothian, Mr. Dudgeon was educated at the Edinburgh Academy—an institution of which Sir Walter Scott was one of the founders, and to which he gave the tutor of his own boys as Rector, the Archdeacon Williams. Sir Walter seems to have imbued this school in an abiding manner with his own love of nature; as it has often been remarked that it produced more scientists and naturalists than any similar institution in the north.

Mr. Dudgeon resided in China for some sixteen years, about the time when Japan was first opened to Europeans; and it was from these islands, as well as from China itself, that he gleaned the specimens of his first mineralogical collection, namely of minerals embedded in rock crystal.

This collection, altogether unrivalled elsewhere, now fills a case in the Edinburgh Museum of Science and Art; and it used to be a source of great pride to Mr. Dudgeon to assert that there were only two specimens in the British Museum which were worthy to be placed beside it.

Shortly after his return to this country in 1850, Mr. Dudgeon became

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associated with Professor Heddle, and they were ever after in every way associated in mineral exploitation, mineral analyses, and mineral collecting.

One of their first enterprises was a Survey of the Färoe Islands. For this a vessel was specially chartered and fitted, quarrymen engaged, and the country searched for the greater part of five months. Similar excursions by yacht followed in the Shetlands, the Orkneys, and part of the Hebrides.

The results, as regards the size and excellence of the specimens collected, being quite commensurate with the scale upon which these surveys were conducted, Mr. Dudgeon ultimately presented the whole of his Scotch collection to the Nation, to form the nucleus of a collection of Scottish minerals.

Shortly thereafter he enriched the general collection of minerals in the Edinburgh Museum by the gift of his general collection, but his sole interest lay in the enriching of the Scottish collection; and his delight was unbounded when he found that the larger collection of his life-long associate was to rest beside and be incorporated with his own. The chief palliative of that associate's grief at his irreparable loss lies in the thought that each day's labour brings him nearer the completion of that which is to stand as an abiding monument to the *originator of the collection of Scottish minerals.*

M. F. H.

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NOTES AND COMMENTS.

THE Society has lost one of its corresponding members in the person of Dr. Frederik Johnstrup, Professor of Mineralogy and Geology at Copenhagen, who died on the 31st December at the age of 76. He was appointed to the Chair in 1866, and published numerous memoirs relating to the Geology of Denmark; his well-known researches on the Geology of Greenland were commenced in the year 1876, and in 1888 he was appointed to the Directorship of the Geological Survey of Denmark.

Among recent changes in the Mineralogical world it may be noted that Professor Chrustchoff has been called from Kharkov to the Chair at the Military Academy of St. Petersburg, and that Dr. J. S. Talmage has been elected to a newly founded Professorship of Geology in the University of Utah; while death has removed the distinguished Mineralogist and Crystallographer, Professor C. v. Haushofer, who since 1889 had been director of the Technische Hochschule at Munich.

An interesting discovery has been announced by Professor Krenner, of Budapest, who describes a mineral containing no less than 59·5 per cent. of thallium, to which he has given the name Lorandite. He finds the mineral to have the formula $TlAsS_2$; it occurs as red tabular or prismatic crystals belonging to the mono-symmetric system, and is found on realgar at Allchar in Macedonia.

We have received from Messrs. George Philip and Son a geological map of Western Australia, executed by Mr. H. P. Woodward, the Government Geologist, which can be confidently recommended to all who desire a clear map of that interesting colony. The numerous gold fields

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to which public attention has been so strenuously directed during the last year are well shown, and the routes of various explorers in the less known parts of the country are clearly indicated. The scale is about 50 miles to the inch.

A Catalogue sent by Messrs. G. L. English, of New York, the enterprising firm of mineral dealers, makes it evident that the interest in minerals is by no means waning in the United States: the Catalogue extends to 124 pages, and with copious figures and descriptions practically constitutes a brief handbook; the very full list of recent acquisitions seems to contain most of the minerals of interest which have been lately reported from various parts of the world.

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REVIEW.

Guide to the Collection of Building Materials in the Natural History Museum of Vienna. [Führer durch die Baumaterial-Sammlung des k. k. Naturhistorischen Hofmuseums.] By Felix Karrer; with a Preface by the Editor, Dr. Aristides Brezina, Director of the Mineralogical Department. Small 8vo, 302 pages, with 40 illustrations. Vienna, 1892.

This guide is the first of the special catalogues which it is the intention of Dr. Brezina to issue for the various collections in the Mineralogical Department of the Natural History Museum in Vienna.

In the introduction, definitions and brief descriptions of the principal rock types are given, and the general plan of arrangement of the specimens is explained. The arrangement is in the first place a geographical one; each country, and in the case of Austria-Hungary each of the principal towns, is represented by a special collection: in each of these collections the various kinds of building material are distributed into groups according to the different uses to which they are applied, *e.g.* road metal, paving stones, building stones, decorative stones, roofing slates, artificial stones, etc.: in each of these groups the species are arranged according to their petrographical relations, and in each petrographical division according to their geological age.

A collection of building materials thus arranged, besides being of great practical value to the architect and builder, and affording considerable interest to the geologist, should also have its attractions for the general public, to whom it gives an opportunity of learning something of the nature and variety of the rocks and minerals employed in the construction of the towns in which they live. A small collection of this kind, to illustrate the several kinds of building material used in the town in which it is situated, would be a useful feature in all local museums. In the Vienna collection we notice that England is very poorly represented by a few specimens only of ornamental and artificial stones.

The guide is illustrated by photo-types of public buildings of many of the principal cities of Europe, with descriptions of the different kinds of stone used in their construction.

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Abstracts.

Blue soda-bearing amphibole from California. C. Palache describes a new amphibole mineral from the crystalline schists near Berkeley, California (*Bull. Geol. Dep. Univ. Cal.*, Vol. I. p. 181, 1894). It occurs in little prisms embedded in clear, mostly untwinned, albite, which is the main constituent of the rock. A clinopinacoidal section gives the extinction angle ($c\ \alpha$) 13°, in front. The pleochroism is very strong: α, sky-blue to dark blue; β, reddish to purplish violet; γ, yellowish brown to greenish yellow. In certain veins which traverse the rock, fracturing the amphibole crystals, the latter show a secondary outgrowth of fibrous green actinolite giving the extinction-angle ($c\ \gamma$) 17°—18°, behind. The blue mineral has a specific gravity 3·126—3·16, and gives the composition

SiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	Total
55·02	4·75	10·91	9·45	tr.	9·30	2·38	7·62	0·27	99·70

It thus stands in some respects midway between glaucophane and riebeckite. In optical characters it closely resembles the mineral described by Whitman Cross from Colorado, which was not analysed (see *Min. Mag.* Vol. IX. p. 249), and the author proposes for it the name "Crossite."

A. H.

A new anorthoclase-augite-rock from Vulcano. W. H. Hobbs describes, under the name "volcanite," a rock ejected in the form of bombs during the eruption of Vulcano, in the Lipari Islands, in 1888. The bulk-analysis of the rock is given in column I. (by Kahlenberg), and corresponds rather closely with that of the dacites, but the mineralogical constitution is quite different. There is a vitrophyric ground-mass enclosing large crystals of felspar, augite, and rarely olivine (?). Most of the felspar shows no twin-striation, and is found to be anorthoclase (analysis II. by Scoular). Subordinate andesine also occurs. The augite is green in slices: its specific gravity is 3·2834, and its composition is shown under III. (by Urban). The ground-mass of the rock is a glassy base full of minute felspar laths and crystallites of augite: its analysis is given by IV. (Kahlenberg). There are holocrystalline patches supposed to represent the relics of inclusions of dolerite. Less common is an acid

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	I.	II.	III.	IV.	V.
SiO_2	66·99	60·01	47·60	67·55	74·57
Al_2O_3	17·56	20·12	4·66	18·04	13·09
Fe_2O_3	1·41	2·82	—	1·18	—
FeO	3·39	not det.	12·78	3·15	—
MnO	tr.	—	tr.	tr.	—
MgO	0·93	0·23	14·56	0·74	—
CaO	4·25	5·15	18·06	3·03	1·32
Na_2O	3·35	6·43	1·50	4·39	
K_2O	0·34	3·67	—	0·11	
H_2O	1·53	0·77	0·50	1·06	
P_2O_5	tr.	—	—	—	
	99·75	99·20	99·61	99·25	

inclusion consisting of a crystalline aggregate of felspar and quartz: a partial analysis of this (by Urban) gave the result V. (*Zeits. deuts. geol. Ges.* Vol. XLV. p. 578, 1894). A. H.

Leucite-bearing rocks in Celebes. Humboldt's statement that leucite was a mineral known only in Europe was first challenged by Vogelsang's discovery of a leucite-basalt in the island of Bawean, north of Java, and other observers have since recorded various leucitic rocks from Java itself. To these A. Wichmann has now added a number of occurrences in the south-western peninsula of Celebes (*Natuurkundig Tijdschr. Ned. Ind.* Part LIII. p. 315, 1893). From Parang-Lowe, near Macassar, he describes a bedded tuff composed largely of fragments of leucite-tephrite, containing crystals of felspar and leucite in a brown base. From the Pangkadjéné river comes a dark compact leucite-basalt with porphyritic crystals of green augite, and partly serpentinised olivine in a ground-mass of little leucite crystals, augite-microlites, octahedra of magnetite, and dark brown globulitic glass. A leucitite from the Masépé river shows abundant leucite in good crystals as a constituent of the otherwise much decomposed ground-mass: augite occurs porphyritically. Another type, from Tempé, has relatively large porphyritic leucites and augites in a microcrystalline ground of leucite, augite, sanidine, magnetite, and apatite. Here the presence of sanidine marks an approach to the characters of leucitophyre. Lastly, from the Walannaë river are described a leucite-basalt with porphyritic augite and leucite in a ground of leucite, augite, olivine, melilite, nepheline, and magnetite, and two

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varieties of leucitite. It is remarkable that the lavas of the Celebes volcanoes belong in general to the widely different type of augite-andesites.

A. H.

The Constitution of the Zeolites. (F. W. Clarke, *Am. J. Sc. XLVIII.* p. 187, 1894). In this preliminary paper the author considers the zeolites as being substitution derivatives of simple normal salts, such as $Al_4(SiO_4)_3$, $Al_4(Si_3O_8)_3$ etc., in the same way as he has previously considered the micas, chlorites, etc. The relation existing between the felspars and the zeolites is shown by anorthite and albite also being derivatives of the same two salts respectively, and by such facts as that many zeolites are derived from felspars, and that many on fusion yield anorthite.

Temporarily regarding all the water as water of crystallisation, and representing the mutually replaceable groups SiO_4 and Si_3O_8 by X, most zeolites fall into one of the two groups:

1. $Al_6X_6R'_6$, n aq. + $Al_3X_3R'_3$, n aq.
2. $Al_4X_6R'_{12}$, n aq. + $Al_2X_3R'_6$, n aq.

as is shown in the following table:—

	First Group.	
Thomsonite	...	$Al_6(SiO_4)_6(CaNa_2)_3 \cdot 7H_2O$
Gismondite	...	$Al_6(SiO_4)_6(CaK_2)_3 \cdot 12H_2O$
Phillipsite	...	$Al_6X_6CaR'_4 \cdot 15H_2O$
Levynite	...	$Al_6X_6Ca_3 \cdot 15H_2O$
Chabazite	from to	$Al_6X_6Ca_3 \cdot 18H_2O$ $Al_3X_3Na_3 \cdot 9H_2O$
Gmelinite	...	$Al_3X_3Na_3 \cdot 9H_2O$
Hydronephelite	...	$Al_3(SiO_4)_3Na_2H \cdot 3H_2O$
Offretite	...	$Al_3X_3R'_3 \cdot 8H_2O$
	Second Group.	
Foresite	...	$Al_4(SiO_4)_6CaH_{10} \cdot H_2O$
Scolecite	...	$Al_4(SiO_4)_6Ca_2H_8 \cdot 2H_2O$
Laumontite	...	$Al_4X_6Ca_2H_8 \cdot 4H_2O$
Heulandite	...	$Al_4X_6Ca_2H_8 \cdot 6H_2O$
Epistilbite	...	$Al_4X_6Ca_2H_8 \cdot 6H_2O$
Stilbite	...	$Al_4X_6Ca_2H_8 \cdot 8H_2O$
Faujasite	...	$Al_4X_6Na_2CaH_8 \cdot 15H_2O$
Natrolite	...	$Al_2(SiO_4)_3Na_2H_4$

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A few details regarding each species are given; thus *thomsonite* has a formula equivalent to anorthite plus water; taking account of the constitutional water, the formula is written—

$$Al_4(SiO_4)_6Ca_3(AlH_2O_2)_2H_4 \cdot 3H_2O.$$

Here the group—$Al{=}(OH)_2+H_2$ replaces Al. The excess of silica in "mesole" is accounted for by small admixtures of Si_3O_8.

Other zeolites do not fall into these two groups, thus: ptilolite and mordenite are salts of $H_2Si_2O_5$; analcite and leucite, being closely allied, are represented by formulæ of the same type.

Leucite. Analcite.

$$Al\begin{matrix} SiO_3 \\ SiO_3-K \end{matrix} \qquad Al\begin{matrix} SiO_3 \\ SiO_3-Na \end{matrix} +H_2O$$

The related minerals okenite, gyrolite and apophyllite are considered as salts of $H_6Si_2O_7$ analogous in structure; apophyllite being written:—

$$Ca \begin{matrix} Si_2O_7 \cdot H_4(CaOH) \\ Si_2O_7 \cdot H_4 \\ Si_2O_7 \cdot H_4(CaOH) \end{matrix} Ca$$

Here potassium partly replaces the group—Ca—OH, and fluorine the hydroxyl. L. J. S.

Formation of Ore Deposits by differentiation processes in basic magmas. (J. H. L. Vogt, *Zeitsch. f. prakt. Geologie*, pp. 4, 125, and 257, 1893).

In the *Geol. Mag.* for 1892 (p. 82) Teall gives a review of a former paper by Vogt on this subject.

The process of differentiation is well illustrated in dykes with basic margins, *e.g.* the Huk dyke in the Christiania district, which has a centre of mica-syenite-porphyry and the margins of kersantite. The ore deposits may be divided into two groups—I. those with oxides, and II. those with sulphides.

I. The separation of oxides (ilmenite and titaniferous magnetite). —Examples of this are the dykes and veins of ilmenite-norite and ilmenite in the labradorite rock and norites of the Ekersund-Soggendal district (South Norway); here there is a continuous series from labradorite rock (with 2 per cent. of ilmenite and 94 per cent. of labradorite), through ilmenite-norite (with usually 40 per cent. of ilmenite), to ilmenite masses (with 99 per cent. of ilmenite and 1 per cent. of labradorite). At Taberg (South Sweden) there is a gradual passage from olivine-hyperite to a magnetite-olivine-rock, and near Kragerö (Norway) are passages from

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olivine-hyperite into an ilmenite-enstatite-rock. In Brazil pyroxene-bearing nephelinite passes gradually into nepheline- and magnetite-pyroxenite.

These concentrations occur in the centre of the eruptive masses, and consist of minerals of the first and second consolidation periods, *i.e.* ilmenite, titaniferous magnetite, and ferro-magnesian silicates. Other heavy metals are only rarely observed, but in the Brazilian deposits are Nb, Ta, and Zr (in baddeleyite).

II. Separation of sulphides (nickel-bearing pyrrhotine and pyrites, rarely with pentlandite, millerite and polydymite). Pyrrhotine, the most important, usually contains 3—4·5 per cent. of Ni+Co, there being 6—8 times as much Ni as Co; the presence of these is not due to the mechanical mixture of pentlandite &c. with the pyrrhotine, but to the isomorphous replacement of the iron. Copper pyrites with 0·5 per cent. of Ni+Co, crystals of pyrites rich in cobalt, and ilmenite also occur, but other minerals are rare; sperrylite is, however, occasionally present in the deposits of Sudbury (Canada).

In Norway and Sweden the deposits occur in hyperites, norites, labradorite-rock, gabbros, &c. The ores are usually strictly confined to the margins of the masses; sometimes there is a gradual passage from gabbro, &c., through pyrrhotine-gabbro and norite to pure ore, at other times there is a sharp junction.

As ferro-magnesian silicates have not been concentrated along with the sulphides, the pyrrhotine-norites, &c., may be considered as norites, &c., with 1—99 per cent. of pyrrhotine; the silicates being embedded porphyritically in the sulphides.

III. A third kind of separation in eruptive rocks is the *separation of metals*. Here are two groups—1, nickel and iron; and 2, platinum and osmiridium. The Disko iron contains Ni, Co, and Cu in much the same proportions as the pyrrhotine deposits. Platinum (with much Fe, Cu, &c., and little Os and Ir) and the Disko iron (poor in Ni) are early stages of the separation processes, while osmiridium and awaruite (rich in Ni) are more advanced stages.

Laws of differentiation of eruptive magmas. There may be three ways for concentration to take place:

1. Mechanical separation of already formed minerals in the mother liquor.

2. Minerals may be first formed and concentrated, and then reabsorbed in the mother liquor.

3. Concentration by diffusion of fluid molecules or ions.

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As the minerals in the ore deposits have been formed *in situ* and are not corroded, only (3) will apply. Magmas may be compared to salt solutions; ores, accessory minerals, and ferro-magnesian silicates being held in solution are therefore the materials which will be concentrated. Temperature differences and gravity have the effect of altering the homogeneity of salt solutions. In an enclosed magma basin, on account of cooling, there will be concentration in the upper portions (Soret's principle), while gravity will give rise to a concentration at the bottom of the basin (Gouy and Chapéron's principle).

The oxide and sulphide separations only occur in basic plutonic rocks, never in volcanic rocks, as the separation processes obviously depend on the time, and never in acid rocks on account of their greater viscosity and their poverty in heavy metals. The sulphide separations, which almost always occur at the borders of the eruptive masses, are easily explained by Soret's principle. On the other hand, the oxide separations, which do not occur at the borders, are not due to differentiation processes arising from temperature differences, but may have been brought about by the influence of gravity, and perhaps also magnetic and electrical forces.

The laws of differentiation are thus very complicated, depending on a whole series of factors, viz. the chemical relations of the fluid molecules, influence of osmotic pressure, gravity, and perhaps also magnetic and electrical forces; properties of solutions, diffusion, viscosity, melting points, the presence of mineralising agents, besides probably many others.

L. J. S.

Canfieldite and Argyrodite (S. L. Penfield, *Am. J. Sc.* XLVII., 1894, p. 451).—The germanium mineral recently described by the author as canfieldite has been shown to be identical with the previously described argyrodite, which was found afterwards to be cubic, instead of oblique as at first stated (Abstract, p. 336, Vol. X.). In the present paper the isomorphous tin compound, which comes from La Paz, Bolivia, is described. The mineral occurs in octahedra modified by dodecahedral planes, and is almost identical with argyrodite in its physical properties. The lustre is brilliant metallic, and the colour is black with the same bluish to purplish tone as argyrodite. H = 2½ – 3 : sp. gr. = 6·276. Analysis gave:

S	...	...	16·22
Sn	...	...	6·94
Ge	...	...	1·82
Ag	...	...	74·10
Zn and Fe		...	·21
			99·29

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This gives the formula $4Ag_2S\cdot(Sn,Ge)S_2$ with Sn : Ge=12 : 5. For this new sulpho-stannate the name canfieldite is now proposed; argyrodite being the isomorphous germanium compound, which partly replaces the canfieldite in the above analysis. As described by Weisbach, the Freiberg argyrodite is hemihedral, but the Bolivian argyrodite and canfieldite are apparently holohedral, with, however, indications of twinning. The only previously known sulpho-stannates are—stannite, franckeite, and the doubtful plumbostannite. Franckeite has recently been described by Stelzner, and in it Winkler has detected a small amount of germanium (*Neues Jahrb.* 1893, II., p. 114). L. J. S.

The Chemical Composition and Related Physical Properties of Topaz (S. L. Penfield and J. C. Minor, Jr., *Am. J.Sc. XLVII.* p. 387, 1894).—The formula usually accepted is that of Groth $[Al(F_2,O)]\,AlSiO_4$, corresponding to an isomorphous mixture of $(AlF_2)AlSiO_4$ with the andalusite molecule $(AlO)AlSiO_4$. Rammelsberg suggests a mixture of Al_2SiO_5 and Al_2SiF_{10} in the proportion of 5:1. It has been previously shown by one of the present authors that hydroxyl frequently replaces fluorine, and it is doubtful if bivalent oxygen ever plays this *rôle;* in confirmation of this it has been found that the variations which topaz shows, both in chemical composition and physical properties, are the result of an isomorphous replacement of fluorine by hydroxyl, and that the formula is $[Al(F,OH)_2]_2SiO_4$ or $[Al(F,OH)_2]\,AlSiO_4$. In the analyses the water was expelled by fusing at an intense heat with sodium carbonate, and collected in a sulphuric acid tube. The fluorine was determined by fusing the mineral with quartz and sodium and potassium carbonates, and precipitating as calcium fluoride. The SiO_2 in six complete analyses varied from 31·93 to 32·82 per cent. and the Al_2O_3 from 55·41 to 56·61 per cent.; while the ratios were almost exactly $SiO_2:Al_2O_3:F+OH=1:1:2$. In the following table it is seen that the optic axial angle for yellow light and the density decrease as the fluorine is replaced by hydroxyl:—

	2E.	Sp. gr.	Fluorine.	Water.
Zacatecas, Mexico	126°28′	3·574	—	0·18
Thomas Range, Utah	125°53′	3·565	20·37	0·19
Nathrop, Colorado	125°51′	3·567	20·42	0·29
Pike's Peak, Colorado	122°42′	3·567	—	0·48
Tenagari, Japan	120°59′	3·565	19·50	0·57
Adun Chalon, Siberia	118°46′	3·562	19·24	0·58
San Luis, Mexico	118°17′	3·575	19·53	0·80
Schneckenstein, Saxony	114°28′	3·555	18·50	0·93
Stoneham, Maine	113°50′	3·560	18·56	0·98
Minas Geraes, Brazil	84°28′	3·532	15·48	2·45
" " "	—	3·528	—	2·50

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It is evident, therefore, that the topaz from Durango, Mexico, mentioned by Des Cloizeaux as giving the largest value of 2E=129°30′, must approach to the pure fluorine compound $(AlF)_2SiO_4$, while that from Mugla, Asia Minor, giving the smallest value of 2E=71°32′, must be the richest in hydroxyl of any topaz yet examined. The indices of refraction show a progressive change along with the variations of 2E, increasing while the double refraction decreases as hydroxyl replaces fluorine. The crystallographic axes are also affected by the isomorphous replacement.

	2E	α	β	γ	$\gamma-\alpha$	$021 : 0\bar{2}1$
Utah	126°24′	1·6072	1·6104	1·6176	0·0104	87°19′
Brazil	86°21′	1·62986	1·63077	1·63747	0·00811	86°55½′

Optical anomalies were only observed in Brazilian crystals, in sections of which an inner rhomb and outer segments are seen, indicating variations in the refractive indices, and the existence of an inner core or older crystal surrounded by a later growth. Des Cloizeaux found that the central and outer segments of such a zonal crystal gave different values for 2E. As the physical properties vary with the composition, such compound crystals must be subject to mechanical strains, giving rise to the optical anomalies.

Similar variations in the physical properties brought about by the partial substitution of fluorine by hydroxyl have been also observed in herderite (Penfield, *Am. J. Sc.* Vol. XLVII. p. 329, 1894), in which are known the pure hydroxyl compound, hydro-herderite $Ca(BeOH)PO_4$, and the hydro-fluor-herderite $Ca[Be(OH,F)]PO_4$ with OH:F=3:2. With topaz the nearly pure fluorine extreme is known $(AlF)_2SiO_4$, and the hydro-fluor topaz from Brazil $[Al(F,OH)]_2SiO_4$ with F:OH=3:1. In both an increase in the hydroxyl is accompanied by a decrease in density and in the optic axial angle, and an increase in the indices of refraction.

L. J. S.

The Formation of Sandstone Concretions (G. P. Merrill, *Proc. U.S. National Museum, XVII.* p. 87).—The loose sandy beds of the Potomac division of the cretaceous, exposed in reservoir excavations in Washington, D.C., contain numerous irregular nodular masses of siliceous sand and marcasite. On weathering, the marcasite at the surface gives rise mainly to sulphates; but when buried in the sand, the partial weathering causes separation of ferric oxide, which segregates in a narrow zone about the nodule, cementing together the sand and giving rise to a hard coating; the sand mixed with the marcasite being left partially filling the cavity of

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these "box-stones." The marcasite may have originated by the reduction of ferrous sulphate solution by the associated lignite. L. J. S.

Penfieldite (S. L. Penfield, *Am. J. Sc.*, XLVIII. 1894, p. 114).—This mineral from Laurium, Greece, described by Genth (*Am. J. Sc.*, p. 260, 1892) as having the composition $PbO \cdot 2PbCl_2$, is now described crystallographically. The crystals are long hexagonal prisms with the basal plane, and a pyramid of the second order, p $(52\bar{1})$; $c:p$ is given as 41°53′, from which $a:c = 1 : 0{\cdot}8967$. Some crystals show steep pyramids of the first order, giving rise to horizontal striations on the prism faces, and causing the crystals to taper to a point. The double refraction is strong and positive. L. J. S.

The cleavage and parting Planes of Oligoclase and Albite, (S. L. Penfield, *Am. J. Sc.*, XLVIII. p. 115, 1894).—Some massive specimens of clear glassy felspar from Hawk mica mine, Bakersville, Mitchell Co., N.C., shown by analysis to be oligoclase with $8{\cdot}6\ Ab + 1An$, exhibit the perfect basal cleavage, together with an imperfect cleavage or parting parallel to the pyramid $(\bar{1}\bar{2}1)$, but the (010) cleavage and the polysynthetic twin lamellæ are absent. As this second abnormal cleavage had previously been taken to be (010) the mineral was supposed to have abnormal optical properties (as regards extinction and position of the optic axes). The indices $(\bar{1}\bar{2}1)$ were fixed by the angle of about 88° for $001 : \bar{1}\bar{2}1$ (calc. 87°25′), and the extinction on the basal plane of 38° − 40° with reference to the edge $001/\bar{1}\bar{2}1$. When the specimens are broken in the direction of (010) they only present curved surfaces of a conchoidal fracture. Other specimens from the same locality present the normal cleavage and polysynthetic twinning, and in these it is easy to produce the (010) cleavage; it is therefore suggested that this cleavage may possibly be the result of separation along the plane of twinning.

A crystal of albite from Amelia, Virginia, on being broken, gave fragments bounded by the basal plane and by surfaces parallel to the prism m (110), and the pyramid o $(\bar{1}\bar{1}1)$; the latter having the appearance of perfect cleavages, but being in reality only partings as they cannot be produced indefinitely. These partings are readily produced by pressure in the direction of the $\bar{b}$ axis. The parting (110) is produced on throwing heated albite into water.

The cohesion relations of the plagioclase felspars may thus show considerable variations. The basal cleavage is always perfect; that parallel

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to *b* (010) is usually distinct, except sometimes when the polysynthetic twin lamellæ are absent, while under certain conditions of pressure or tension partings parallel to *m* (110), *o* ($\bar{1}\bar{1}1$), and ($\bar{1}2\bar{1}$) may occur.

L. J. S.

The Identity of Hydrofranklinite and Chalcophanite (S L. Penfield and D. A. Kreider, *Am. J. Sc.* XLVIII. p. 141, 1894).—Hydrofranklinite was described by W. T. Rœpper as a hydrous oxide of iron, zinc and manganese, crystallising in brilliant, iron-black octahedra, with perfect octahedral cleavage, and occurring on manganese ore at Sterling Hill, near Ogdensburg, New Jersey. The analysis by the present authors (a previous one not having been made) agrees closely with the formula $RO{\cdot}2MnO_2{\cdot}2H_2O$, where R=Fe and Zn in the proportion of 8:13. It is also shown that the apparent octahedron consists really of a rhombohedron with the basal plane, and that the perfect cleavage is basal. Sp. gr. 4·012. The mineral is thus the same as G. E. Moore's chalcophanite, from the same locality, in which, however, R=Zn and Mn, and the crystals are tabular in habit.

In separating the material for analysis, the fused double nitrate of silver and thallium, as suggested by *Retgers*, was used. This double salt, which contains the two simple salts in equal molecular proportions, fuses at 75°C, has a specific gravity of about 5, and is miscible in all proportions with water, the melting point falling to 50° or 60° as water is added. In the paper an improved apparatus is described, consisting of a test-tube, into a hole in the bottom of which a rod fits, acting as a plug, to be raised to allow the escape of the denser part of the separated material.

L. J. S.

Large Fluid Enclosures in Gypsum from Sicily (Hy. Sjögren, *Bull. Geol. Inst. Upsala, Vol. I.* p. 277, 1893).—Associated with sulphur and aragonite at Cianciana, Girgenti, are large, transparent, lenticular crystals of gypsum (0·3 m. long), with irregular, branching, fluid enclosures, 20—30 mm. in extent; others are flat, extending along the best cleavage. All the enclosures show bubbles, which do not diminish in size when the crystal is slightly heated. On boring to the largest cavity, 8 cc. of a neutral liquid were obtained; sulphuretted hydrogen, at not a very great pressure, escaping from the cavity. The water contained 4·02 per cent. of saline matter, which had the composition:—

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K_2SO_4	...	...	3·7 per cent.
Na_2SO_4	...	...	11·4 ,,
$CaSO_4$	...	...	9·7 ,,
NaCl	...	...	66·2 ,,
$MgCl_2$	...	...	9·0 ,,

The solution is thus very similar in composition to sea water, and to the water of several sulphurous springs (*e. g.* the Kaiserquelle at Aix-la-Chapelle).

These enclosures may throw some light on the origin of the sulphur, to explain which two views have been advanced. According to one it has originated by the reduction of gypsum by organic matter, in isolated lagoons, where the less soluble salts have been precipitated. The mother-liquor of such a lagoon does not however correspond in composition to that of the enclosure examined. The other view is that the sulphur and gypsum have been deposited by springs containing sulphuretted hydrogen, and in support of this it is seen that the composition of Sicilian spring-waters of the present day agrees with that of the enclosure. L. J. S.

Artificial Production of Anhydrite (R. Brauns, *Neues Jahrb. f. Min.* II., p. 257, 1894).—The experiments which have hitherto been successful in the artificial production of anhydrite, have not been made under the same conditions that have obviously existed in nature. It has been formed by fusing together calcium sulphate and chloride, but the volcanic occurrences of the mineral are rare (Vesuvius); the methods in which gypsum is heated in a sealed tube with chlorides, or digested with hot sodium chloride solution, could not be the same as those which have taken place in the deposition of anhydrite from concentrated sea water.

In the author's experiments, a large drop of a saturated solution of sodium and potassium chlorides is placed on a microscope slide, at its side a drop of calcium chloride solution, and opposite this a drop of magnesium sulphate solution, the two drops are then brought into contact by a narrow path and allowed to evaporate. As diffusion takes place between the drops anhydrite is deposited, and here and there gypsum, while the alkaline chlorides near the calcium chloride drop separate out as octahedra or cubo-octahedra (this form being due to the influence of the calcium and magnesium chlorides). The clear, transparent anhydrite crystals have the form of short prisms with the ends rounded, and average 0·025 mm. in breadth and 0·035 in length, the largest having twice these dimensions. They are often united together in the middle, and some-

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times form small globules, behaving in polarised light as radially-fibrous aggregates. The smaller axis of optical elasticity is parallel to the length of the prism. On removing the salt crystals and adding a little water, the anhydrite crystals are immediately corroded and gradually disappear, and, on allowing to evaporate, gypsum, and not anhydrite, crystals are formed. In case the amount of water added is not enough to completely dissolve the anhydrite, gypsum crystals are deposited around the corroded forms; or sometimes when the gypsum crystals do not grow on the surface of the anhydrite, but near to it, the former substance can be seen to grow at the expense of the latter. Calcium sulphate is therefore one of those substances which crystallise in compounds poor in water from saline solutions. A similar instance is seen with magnesium sulphate, which crystallises as kieserite ($MgSO_4 \cdot H_2O$) instead of as epsomite ($MgSO_4 \cdot 7H_2O$), when the solution contains magnesium chloride: and sodium sulphate from a pure aqueous solution separates as glauberite ($Na_2SO_4 \cdot 10H_2O$), but in the presence of sodium chloride as thenardite (Na_2SO_4). In nature, anhydrite, kieserite, and thenardite crystallise from saline solutions, so that the view is well grounded that salts in solution hinder the separation of compounds rich in water, having the same effect as an increase in temperature. L. J. S.

Occurrence of Nepheline Syenite in the Township of Dungannon, Hastings Co., Ontario (F. D. Adams, *Am. J. Sc. XLVIII.* p. 10, 1894).—This large area (extending for seven miles in one direction) of nepheline syenite is the first that has been found in the Laurentian of Canada: it is partly bordered by crystalline limestone, and is intimately associated with a fine-grained biotite granite (aplite). The rock has a hypidiomorphic granular structure, and is frequently massive but sometimes distinctly foliated. The texture is usually coarse, sometimes very coarse, with nepheline individuals two-and-a-half feet across. The essential constituents are nepheline and plagioclase, with either a little brown mica or dark green hornblende; the accessories are scapolite and calcite, and less abundantly garnet, zircon, sodalite, magnetite, pyrites, and apatite. The clear, colourless nepheline, which has a vitreous rather than a greasy lustre, is the most important constituent. The plagioclase, which is albite, is seldom very abundant, but is in most cases present. There are two varieties of hornblende, as seen by the extinctions, the optic axial angle, pleochroism, and composition, one being common hornblende and the other allied to arfvedsonite. Both contain considerable amounts of soda,

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Scapolite is present as an original constituent in clear, colourless grains. Since the rock is fresh, the calcite must also be original, as is also seen by its mode of occurrence in well defined, more or less rounded, individuals, with, and often enclosed in, the other minerals. Bright blue sodalite is present as scattered grains or strings, and at places in large masses. It is associated with strings of iron ores, and is traversed by cracks filled with reddish secondary orthoclase.

The author defines a nepheline syenite as a rock composed essentially of nepheline and an alkali felspar, instead of one composed of nepheline and orthoclase, as the present rock differs greatly in composition from typical specimens of theralite. This Dungannon rock approaches the nepheline syenite of Litchfield, Maine ("Litchfieldite"), which has orthoclase as well as albite, and further contains neither augite nor sphene (*cf.* Abstract, Vol. X. p. 345). In places where the rock consists only of nepheline with a little hornblende or mica, it is really an ijolite rather than a nepheline syenite.

In an accompanying paper by B. J. Harrington (p. 16) analyses and descriptions are given of the nepheline, sodalite, and the orthoclase in the sodalite. L. J. S.

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THE MINERALOGICAL MAGAZINE

AND

JOURNAL

OF THE

MINERALOGICAL SOCIETY.

No. 50. SEPTEMBER 1895. Vol. XI.

On the Structure-Planes of Corundum.

By Professor JOHN W. JUDD, C.B., LL.D., F.R.S., &c.

[Read April 10th, 1894.]

WHILE examining the fine series of corundums brought from Burma by Mr. C. Barrington Brown, F.G.S., and comparing them with specimens obtained from Ceylon, Southern India, the United States and other localities, I have been led to devote especial attention to the curious "parting-planes" which are sometimes found in crystals of this mineral, but which, in other cases, appear to be entirely wanting. In making these comparisons, I have had the great advantage of being able to refer to the fine collection of corundums in the British Museum (Natural History) at South Kensington, and have to gratefully acknowledge the advice and assistance which have been so freely afforded to me at all times by Mr. Fletcher and Mr. Miers.

According to the statements made in most treatises on mineralogy, corundum is a mineral with two cleavages, one parallel to the basal plane $0R$ (111), and the other to the primitive rhombohedron. In recent years,

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however, this statement has been modified by some mineralogists. The Count de Bournon, indeed, in his original memoir on the mineral (*Phil. Trans.* 1802, p. 266) pointed out that corundum exhibits cleavage only in certain cases, and that the less altered the mineral is the more difficult is it to produce "cleavage fractures." In 1874 Max Bauer, as the result of his observations on the series of corundums in the Berlin collection, was led to conclude that all the partings or divisional planes of the mineral are distinct from cleavage-planes.[1]

Tschermak in 1883 refers to these division-planes as "planes of parting" (Absonderung),[2] and this course is also followed by Dana in the 6th edition of the *System of Mineralogy*.[3]

In his classical paper on corundum, published in 1802,[4] the Count de Bournon pointed out that some corundums (especially sapphires) show no appearance of possessing cleavage, but break with a fracture which is either conchoidal or splintery. Experiments which I have made with a great number of specimens confirm this observation of de Bournon, and show that, when unaltered, corundum is quite destitute of any trace of cleavage, and further that the tendency to break up along certain planes is due to incipient change, resulting either from the action of mechanical or chemical forces, or from both of these in combination. The fracture of *unaltered* corundum is, according to my experience, strikingly similar to that of quartz, and not unfrequently is beautifully conchoidal.

Let us now proceed to consider the crystallographic planes along which "parting" has been observed in corundum.

I. Specimens of corundum are continually found terminated by basal planes $0R\{111\}$, which have evidently been produced by the transverse fracture of crystals. It is noteworthy that in these cases the basal planes often exhibit a pearly lustre, markedly different from the vitreous or adamantine lustre of the proper crystal-faces. Not unfrequently, however, the lustre of this parting plane parallel to the base is sub-metallic, being sometimes accompanied by schiller-phenomena. That this breaking up of crystals is not due to cleavage is at once shown by the fact that it is usually quite impossible to produce any parallel partings, the corundum often breaking with an irregular or conchoidal fracture like quartz. It is noteworthy, also, that perfect as is this parting along

[1] *Zeitsch. d. d. geolog. Gesellsch.* Vol. XXVI. (1874), pp. 186-193.

[2] *Lehrbuch der Mineralogie.* 1st Ed. (1883), p.

[3] *System of Mineralogy*, 6th Ed. (1892), p. 211.

[4] Description of the Corundum Stone and its varieties, &c. *Phil. Trans.*, XCII. (1802), pp. 233-326.

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the basal plane, it is liable to interruption, the separation often deviating from the original plane, and following another which is near to, but parallel with it. This is especially well seen when the surfaces are studied under the microscope by reflected light.

II. The remarkable separation of some specimens of corundum along the rhombohedral planes {100} is well known to all mineralogists. Tschermak calls attention to the fact that this parting parallel to the rhombohedron in corundum often shows itself strongly developed along two only of the rhombohedral faces, and not at all, or very feebly, along the third, and he interprets this as indicating a monosymmetric structure of the crystals. (*Min. und Petr. Mittheil.* Vol. I. (1878), p. 364.) Upon weathered crystals and basal sections the traces of these parting planes are often seen very conspicuously as deep striæ; and in the case of much altered corundum crystals—like those found in the Eastern United States—the crystals yield to pressure when placed in a vice, in just the same way as does calcite when subjected to the Baumhauer experiment. There appears to be a certain amount of variation in the position of these parting planes. Mügge, to whose researches on the structure-planes of minerals we are so greatly indebted, at one time thought that the deviations from the normal angles of the primitive rhombohedron were so great as to indicate a separation along the planes of a more acute rhombohedron ($-2R\ \{\bar{1}11\}$)[1]; but his subsequent studies led him to abandon this view, though his measurements show some striking discrepancies, amounting in some cases to several degrees between the true and observed angles in these parting planes.

III. The third parting plane in corundum is less marked than the other two, and was, I believe, first noticed by von Lasaulx.[2] This parting, which is parallel to $\infty P2\ \{10\bar{1}\}$, seldom gives rise to an actual breaking up of the corundum crystals, but can be well observed in thin sections under the microscope. It has been especially noted in corundums from Ceylon, and in the variety found in the granite of the Riesengebirge. It is in the beautiful corundums exhibiting concentric growth from the Chantabun Hills in Siam, and in others said to come from Thibet, that this parting is, however, most noticeable. Certain concentric shells of these remarkable crystals are conspicuous owing to the internal reflections produced by these parting planes, while other portions in the same crystal appear to be equally or quite

[1] *Neues Jahrb. für Min.*, &c., 1884, I. 220.

[2] *Zeitschr. für Krystall.* X. (1885), pp. 351, 353, 364.

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destitute of this peculiarity. The traces of this parting appear on the basal plane, when their sections are studied with the microscope, as a series of very thin but remarkably sharp rectilinear rifts which are parallel to the sides of the hexagonal prism $\infty P2$ $\{10\bar{1}\}$.

It is the presence of these rifts, as pointed out by von Lasaulx, which gives rise to the remarkable asterism so conspicuous in certain varieties of corundum. It is certain, however, that the phenomenon of asterism is in other cases due to the presence of needles and plates of rutile[1] or other minerals intersecting at angles of 60°, and forming the so-called "sagenite-web" and similar structures. Such a "sagenite-web" may be detected in some corundums under the microscope, and is precisely similar to the structure which gives rise to the asterism in the phlogopite from Burgess County, Canada, and other localities.

That these three parting planes are not due to cleavage is perfectly clear. They are certainly altogether absent from corundum which has not undergone incipient alteration.

It may be well to remark at the outset of our inquiry concerning these three parting planes, that while II. (the parting parallel to the rhombohedron R follows a twinning plane of corundum, I. (the basal plane $0R$) is one which, though a possible twinning plane, has never been observed as such in this mineral; while III. (parallel to the hexagonal face $\infty P2$, which is a plane of symmetry), can never be a twinning plane.

IV. Corundum crystals sometimes appear to break up along planes passing through the vertical axis at right angles to the prism-faces. These are probably due to the twin combinations (trillings) described by DesCloizeaux, Mallard, Tschermak, von Lasaulx and other authors.

We will now proceed to consider the nature and origin of each of these parting planes of corundum.

I. When thin sections of corundum are studied under the microscope, a series of rifts, more or less sharp and rectilinear, can be seen lying parallel to the basal plane $0R\{111\}$. By employing high powers these rifts can be resolved into cavities having a slight thickness as compared with their area, and often assuming the form of negative crystals. The cavities are sometimes empty, at other times filled with the products of alteration—either diaspore or some hydrated silicate formed from it. It is the presence of these cavities, either empty or filled with diaspore or hydrous silicates,

[1] Tschermak has in some cases proved the needles present in corundum to be rutile, by their tetragonal symmetry and their prism angles. *l.c.*, p. 361.

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which gives rise to the pearly lustre on the $0R$ face of parting. More rarely, compounds having a metallic or submetallic lustre are developed in the cavities, and these give a metallic lustre to the cleavage face, as in varieties from Siam and Thibet. The fact that in other parts of a crystal which is thus traversed by partings along the basal plane, the ordinary conchoidal fracture may be exhibited, is evidence that the production of the cavities is a more or less local phenomenon.

It is clear, therefore, that the parting along the basal plane of corundum is of the same nature as that produced in the variety of orthoclase known as murchisonite, and in the variety of augite known as diallage. The plane $0R$ (111) is a solution plane, and parallel to this plane cavities are produced, of the nature of negative crystals, which have a great development in that plane but are of very insignificant thickness. These negative crystals sometimes appear to have the triangular form so characteristic of the natural etched figures (Verwitterungs-figuren) which are frequently exhibited on the basal plane of corundum. At other times they exhibit remarkable irregularities of form, but always show a tendency to be bounded by the rhombohedral faces.

That the basal plane is a *solution plane* of corundum is shown by the fact that the crystals from Burma and other localities which have undergone partial conversion into diaspore and hydrous silicates exhibit a remarkable step-like structure (resembling that of "Babel-quartz" on a very minute scale), showing that the chemical disintegration of the crystal has been governed by the existence of these solution planes. This fact is beautifully illustrated in the fine ruby presented to the British Museum by Mr. Ruskin, which exhibits the shaly structure due to corrosion and the natural etched figures in a very striking manner. I have no doubt that this fine ruby came from Burma, and many small specimens which I have examined from the same locality exhibit similar characters. As in the case of murchisonite and diallage, the multiplication of cavities along certain planes gives rise to a plane of weakness or a parting plane in the crystal along which it readily divides.

II. The planes parallel to $R\{100\}$ are twinning planes of corundum, and *lamellar twinning* on these planes is very common in crystals of this mineral. As has been so well shown by Mügge, there is every reason to believe that the lamellar twinning of corundum is, like that of calcite, felspar, and other minerals, of mechanical origin, and has been developed by pressure.[1] It may be, however, as suggested by von Lasaulx,[2] that

[1] *Neues Jahrb. für Min.*, 1886, I., p. 147.
[2] *Zeits. für Krystall.*, X. (1885), pp. 364-5.

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the strains set up in a crystal during its gradual growth may produce alike the optical anomalies and the twin-lamellæ. But whether produced during the growth of the crystal or long subsequently, the *lamellar twinning* is certainly not an essential character, but a secondary and accidental one. The whole crystal may be destitute of any trace of lamellar structure; or the lamellæ may be developed in certain concentric shells or patches of the crystal, and be absent from others; or it may be well shown in the case of one or two of the rhombohedral planes, and almost or quite wanting in the others, as pointed out by Tschermak. Moreover, in their irregularities and flexures, as well as in the capricious mode of their development, these lamellæ exactly resemble the often curved and distorted lamellæ found in calcite, felspar and quartz.

That the planes bounding the twin lamellæ parallel to R {100} become *solution-planes* there cannot be the smallest doubt, and crystals are sometimes found in which more than one-third of the corundum has been converted into diaspore and various hydrous silicates by chemical changes set up along these planes. Beautiful examples of sapphire thus altered were brought from Ceylon by Mr. C. Barrington Brown and by Mr. Baddeley.

The production of negative crystals and other cavities along these rhombohedral faces, and the manner of their infilling by diaspore, hydrous silicates and sometimes by material having a metallic lustre, can often be studied under the microscope.

III. Thin sections of corundum show that the rifts parallel to $\infty P2$ $\{10\bar{1}\}$, when intersected, appear as fine lines. These under the microscope are seen to be sections of negative crystals, either empty or partially or wholly filled with decomposition products. The cavities in question are generally developed on a smaller scale than those parallel to the basal plane, but are perhaps more numerous. They are often the cause of the very distinct sheen (" schiller ") which is exhibited by many varieties of corundum. When such varieties are cut *en cabochon*, with the centre of the curve opposite to the apex of the crystal, the phenomenon of asterism is exhibited. Light traversing the mass is reflected from the surfaces of these negative crystals, owing to the difference between the refractive index of the contents of these cavities and that of the mineral in which they occur. Owing to the symmetrical disposition of these enclosures parallel to the hexagonal faces, the well-known six-rayed star is produced when a strong light falls upon them. In some cases the different zones of which the corundum crystal is built up show remarkable differences in their susceptibility to alteration. In these cases we find zones exhibiting

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a very striking " schiller " alternating with others which retain their perfect translucency. Nowhere do we find this better illustrated than in some of the corundums from Ceylon, of which there are fine examples in the British Museum. In many other cases, like the crystals from Siam and Thibet, we find the zoned structure of corundum crystals strikingly intensified by the development of schiller and other structures in certain of the zones, while other zones are comparatively unaffected. It is sometimes difficult, however, to determine whether the structures in different zones of the corundum crystals are of primary or of secondary origin.

IV. The rarer partings at right angles to the prism-faces, and marking the planes of composition of the trilling combinations, also appear to be due in the same way to chemical alterations taking place along these structure-planes of the complex crystal.

Taking all these facts together, we are led to conclude that corundum has at least three sets of structure-planes, but that none of these can be regarded as true *cleavage*. Two of these structure-planes, those parallel to $0R$ {111} and to $\infty P2$ {10$\bar{1}$}, are normal solution-planes; the third set of structure-planes, those parallel to R {100}, are gliding planes, which, when developed, become secondary solution-planes.

We thus see how complete is the parallelism between the phenomena of the structure-planes in corundum and those exhibited by calcite felspars, augite, hornblende, sphene and many other minerals, which have been studied from the same point of view.

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On some simple Massive Minerals (Crystalline Rocks) from India and Australia.

By Professor John W. Judd, C.B., LL.D., F.R.S., &c.

[Read February 5th, 1895.]

In recent years, the respective provinces of Mineralogy and Petrography have become much more clearly defined than was formerly the case. We no longer include uncrystallised substances, like obsidian, tachylyte and coals among mineral species; and, on the other hand, we recognise the fact that many materials originally analysed and treated as homogeneous—such as lapis-lazuli, emery, and many similar materials—are really mineral aggregates or rocks, and thus come within the domain of the petrographer. This last advantage has been one of the most important of those which have resulted from the application of the microscope to the study of inorganic bodies.

There still remains, however, one class of substances which may be regarded as equally within the spheres of study of the mineralogist and the petrographer. I refer to the materials called by the former "massive varieties of a mineral," and by the old petrographers distinguished as "simple crystalline rocks." These substances are essentially composed of crystals of one species of mineral, more or less perfectly developed, such as olivine, augite, garnet, epidote, topaz, &c. It would, I think, be a great convenience if, instead of giving fanciful names from localities to these rocks, they were distinguished as olivine-rock, augite-rock, garnet-rock, &c., as was done by Macculloch and the old German petrographers.

While engaged in studying the fine series of rocks and minerals brought from Upper Burma by Mr. C. Barrington Brown, I have had my attention directed to some rocks of this class which have not hitherto been described. The circumstance that a number of my friends and former students, resident in India, were able to make inquiries and supply me with trustworthy information with respect to localities, &c., has led me to try to clear away some errors that had crept into the labelling of specimens in public collections, and to obtain new light on

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the nature and mode of occurrence of very interesting materials. To Mr. T. H. Holland, F.G.S , Deputy Superintendent of the Geological Survey of India, Mr. P. Bosworth Smith, F.G.S., formerly Government Mineralogist at Madras, and Dr. J. W. Evans, F.G.S., formerly in the service of the Rajah of Junagadh, I am particularly indebted. I have also received much aid from Mr. F. R. Mallet, F.G.S., who has supplied me with valuable specimens and information, and from Mr. C. Barrington Brown, F.G.S., who has visited both Ceylon and New South Wales since his exploration of Upper Burma.

Corundum-Rock.

Corundum often occurs in the Eastern States of North America in crystals of large size, but these crystals are seldom, if ever, aggregated into a rock. Emery is a rock, but not a simple one ; for the researches of J. Lawrence Smith and Tschermak show that emery is made up of corundum (sapphire), magnetite, tourmaline and some other minerals.

In several parts of India, however, we find massive rocks made up, essentially, of corundum crystals, and these may fitly be called "corundum rocks."

The best known, and probably the largest deposit of corundum-rock which has been described, is that made known to geologists by the researches of Mr. F. R. Mallet, F.G.S., formerly Superintendent of the Geological Survey of India,[1] as being found at Pipra in South Rewah.

The rock is described by Mr. Mallet as occurring in a small hill between Pipra and Kádopání, about a mile east of the River Rehr, the rocks here striking irregularly about E.N.E. and W.S.W. The thickness of the mass could not be accurately determined owing to the quantity of *débris* lying about. Mr. Mallet, however, estimated the breadth of the outcrop, where thickest, to be 90 feet, and the mass is nearly vertical, and it was traced for about half-a-mile. The other rocks with which this great mass of corundum-rock seems to be interfoliated are as follows:—

a. White quartz-schist.

b. Hornblende-rock passing into jade.

c. White tremolitic quartz-schist (fibrous).

d. White and green jade, containing some purple corundum, "euphyllite" and schorl.

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1 *Records of the Geological Survey of India*, Vol. V. p. 20, and Vol. VI. p. 43. Also *Manual of the Geology of India. Mineralogy*, p. 48.

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e. Bed of corundum-rock, reddish, purplish, or gray, with "euphyllite," schorl and diaspore in the cracks.

f. Porphyritic gneiss with hornblende-rock.

Although no indication was found that the 90 feet of rock was not composed entirely of corundum, it may nevertheless contain some subordinate bands of other rocks.

The corundum-rock is described by Mr. Mallet as containing in its cracks larger crystals of corundum, with green mica ("euphyllite"), black tourmaline, and kyanite in radiating aggregates of a reddish colour.

The green mica was analysed by Mr. Tween, with the following result:

Silica	43·53
Alumina	43·87
Oxide of Chromium	·91
Lime	1·45
Potash	7·80
Water	4·60
	102·16

This mineral, though in composition similar to "euphyllite," may equally well be placed with the chromiferous muscovite or Fuchsite.

By the kindness of Mr. Mallet I have been able to study microscopically two varieties of this rock, and a third specimen, almost certainly from the same locality, which was preserved in the British Museum collection, has been supplied to me by Mr. Fletcher.

The rock has a beautiful purple tint, and a specific gravity varying from 3·84 to 3·88. The least dense varieties are those in which a large quantity of mica and other secondary minerals have been developed. Under the microscope it is seen to be almost made up of prismatic crystals and grains of corundum, which occasionally show the secondary parting (gliding-planes) following the primitive rhombohedron. The accessory minerals present are rutile, picotite (chrome-spinel)—of dark coffee-brown colour and isotropic—diaspore, and the green mica ("euphyllite" or "fuchsite").

The corundum is as a rule purple in colour, of a tint well known in the so-called oriental amethyst. Usually, however, the colour and pleochroism are not strong when the mineral is examined in tolerably thin sections, In one very interesting specimen, however, given to me by Mr. Mallet, a remarkable phenomenon is exhibited. There are groups of intensely coloured and highly pleochroic corundum scattered about in the midst of the pale coloured mineral. That this highly coloured material is simply

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corundum is shown by the fact that the crystals with intense pleochroism have the same refraction, double-refraction and extinction as those which are nearly colourless; and cases may be found in which one part of a prism is deeply coloured and pleochroic, while the other part is almost colourless. Occasional grains of sapphire occur, in which the colour given with the ordinary ray is blue, and with the extraordinary ray pale straw-yellow. In the deep purple variety *O* is a rich purple, *E* very faint yellow. The groups of highly coloured corundum appear to be generally portions of crystalline masses which extinguish simultaneously, and the rock has thus a "micro-poicilitic" structure.

A somewhat similar case of the occurrence of an intensely coloured and highly pleochroic variety of a mineral, side by side with the ordinary type, is afforded by the variety of epidote from Glencoe, to which the name of "withamite" has been given. To all appearance the colour of this mineral must be ascribed to a manganese-compound, and the colour and pleochroism is much more striking than that of piedmontite itself. Dr. Heddle, in his analysis of withamite, however, found only 0·14 per cent. of MnO, while the piedmontite of St. Marcel contains, according to Rammelsberg, 15 per cent. of Mn_2O_3. In studying cases like these, one cannot help being reminded of the interesting researches of Senarmont, which proved that a colourless salt may be rendered intensely pleochroic by introducing into it, while crystallisation is going on, a dye stuff like logwood. It is probably the condition of oxidation, and not the quantity of the manganese compound which determines the colour and pleochroism both in Withamite and in these corundums.

Mr. Holland has, at my request, made careful inquiries as to the existence of a similar purple corundum-rock in the Salem district, and he has visited the district; but can find no evidence of any such rock having ever been detected in it. I think there can be little, if any doubt, that the rock in the British Museum, which was supposed to have come from Salem and to have formed part of the Greville collection, is really from South Rewah.

Mr. Holland has, however, furnished me with a specimen of another corundum-rock, and much valuable information concerning its mode of occurrence. It is found at Hunsúr Talúg in the Mysore State. The rock is stated by Mr. Holland, who visited the district during one of his vacations, to crop out along a line running N.N.W. and S.S.E. or N.W. and S.E., at Singanamasanhalli and Nadapanhalli, whilst water-worn fragments have been found along the same line at Hunsúr, Modur and Ramenhalli—a line about 30 miles long to the N.N.W. Still farther

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N.N.W., corundum is found again at Upinangadi in the South Kanara district. Associated with the corundum-bearing band are various hornblendic rocks with an imperfect foliation N.N.W. and S.S.E. to N.W. and S.E. The most prominent of these are hornblende-felspar granulitic rocks and narrower bands of amphibolite. Although the amphibolite bands are generally parallel to the common foliation, they sometimes break across the older rocks and prove their intrusive nature by bifurcating in veins. The corundum-rock is very frequently decomposed to a fine soft product, like agalmatolitè, and in this pinitic product Mr. Holland has found abundant scales of graphite (Nadapanhalli); but he has never seen graphite in fresh specimens of corundum-rock itself.

The corundum-rock of the Mysore State, of which a specimen from Hunsúr Talúg has been sent to me by Mr. Holland, presents many features which distinguish it from that of Pipra in South Rewah. It is of a gray colour, composed of crystals of much larger size than those of the Pipra rock, and has a specific gravity of 3·63. Studied in microscopic sections it is seen to be made up of grains of nearly colourless corundum, almost all of which exhibit the secondary twinning-planes parallel to the faces of the primitive rhombohedron. In very thin sections the gray colour of the mass is seen to be due to the numerous dark coloured inclusions, arranged parallel to the twinning planes and, like them, probably of secondary origin. The other minerals present in the rock are diaspore and other alteration products of corundum, and a biotite with the usual high pleochroism and absorption. The decomposition products scattered through this corundum-rock are in places stained red by hydrous ferric oxide, and in other places green by chlorites.

Massive corundum or corundum-rock has been reported to occur at other points in India, but as yet I have received no definite information or specimens to substantiate the statements.

Fibrolite-Rock.

Among the minerals which de Bournon pointed out as frequently accompanying corundum in India were the two new species which he named "indianite" (anorthite) and "fibrolite" (sillimanite). The latter mineral is now known to occur very frequently in the more acid metamorphic rocks, and to frequently accompany corundum. Among the rocks which are found with the corundum-rock of the Mysore State two very interesting kinds have been sent to me by Mr. Holland. One of these is a hornblende-olivine rock, which may be referred to the cortlandites of the late Dr. G. H. Williams and the "hornblende picrites" of many

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authors. The other rock is almost wholly made up of matted prisms of fibrolite. The rock is remarkable for the different sizes of its constituent minerals; the fibrolite sometimes forming crystals 10 to 20 millimetres in length and 2 or 3 millimetres broad, while others are of microscopic dimensions. All give the usual optical characters of the mineral, its cleavage, high double-refraction, and characteristic cross-fractures. The rock is of a dark gray colour, and has a specific gravity of 3·05.

Tourmaline-(Schorl)-Rock.

Petrographers are well acquainted with many rocks in which tourmaline, and especially the variety schorl, is one of the principal constituents. Most of these rocks can be shown, like the luxullianite, so fully described before this Society by Professor Bonney, to be alteration products from granite and similar rocks.

Among the remarkable Indian rocks which have recently been brought to my notice, however, is a tourmaline- or schorl-rock, of a totally different character to any hitherto described. I am indebted to my friend Mr. P. Bosworth Smith for specimens of this remarkable rock and notes upon its mode of occurrence.

The rock has been found over a very wide area. It occurs as fragments in the Kolar gold-field in the Mysore State, and has been traced thence into the North-Arcot and Salem districts of the Madras Presidencies. The rock has not been found *in situ* in the Kolar district, but veins of quartz full of tourmaline, some of which, like one at Nandydroog mine, are 7 to 8 feet wide, cut across the gold-bearing reef of the district nearly at right angles. Mr. Bosworth Smith subsequently found the rock *in situ* at Chota Nagpur, and in pebbles at Barry's Hill in the Bengal gold-mines in Northern India.

The rock from all these districts presents tolerably uniform characters—it is of a black colour, sometimes dull in the fractured surface, and sometimes with a velvety lustre. It nearly always presents a strikingly fibrous appearance, and the specific gravity of the rock was found, as the result of many careful determinations made by Mr. Bosworth Smith, to vary between 3·02 and 3·11.

In thin sections, the rock is seen to be made up of acicular crystals, often twisted and bent, of a mineral with very marked pleochroism and high absorption. These fibres often show the cross-fractures so constantly seen in fibrolite—and it was at first thought that the mineral might be a highly coloured and abnormal variety of sillimanite—though the optical characters pointed so strongly to tourmaline.

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All doubt as to the nature of the mineral has been set at rest, however, by the following analysis made for me in the chemical laboratories of the Royal College of Science under the superintendence of Mr. Chapman Jones, F.C.S., F.I.C.:—

Silica	35·94
Alumina	31·22
Ferrous Oxide	9·23[1]
Lime	1·66
Magnesia	5·53
Soda	3·96
Water	3·55
Boric Acid...	9·08[2]
	100·17

Lithium was found spectroscopically in the residue of the alkalies.

The following were tested for particularly, but no traces of them could be detected: fluorine, phosphoric acid, manganese, potassium and titanium.

Mr. Riggs, in his investigation of the chemical character of the tourmaline, was unable to find fluorine in many examples of the mineral.[3]

The microscopic characters of this rock are very interesting. The portions with dull lustre and wood-like fracture are seen to contain many prisms from 0·1 to 0·2 of a millimetre in diameter; the prisms, which are sometimes straight and at other times bent and twisted, possess all the optical characters of tourmaline—the strong absorption for the ordinary ray and the dichroism (O, blackish brown; E, bluish gray),—and they exhibit a marked parallel arrangement. Between them is a material which by higher and higher powers of the microscope is resolved into aggregations of similar prisms of minute dimensions. The portions of the rock which have a velvety or almost resinous lustre, inclining to vitreous, can only be partially resolved even by the highest powers of the microscope into crystalline individuals, but the interstitial matter does not behave like a glassy substance by being isotropic between crossed nicols. The dull and fibrous and the black velvety portions of the rock alternate with one another like the different portions of a banded lava.

[1] No attempt was made to separate the FeO from any Fe_2O_3 that might have been present.

[2] A second determination of the boric acid gave 9·11.

[3] *Am. Jour. Sci.*, Vol. XXXV. (1888), p. 35.

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Among the different varieties of schorl-rock from Cornwall, Saxony, &c., I have never seen any fibrous forms in the least resembling this remarkable Indian variety.

From the neighbourhood of Bingera, in New South Wales, Mr. C. Barrington Brown has collected two very interesting rocks, each essentially composed of a single mineral. These rocks occur as dykes in a great mass of serpentine forming the south-east side of the Bingera Valley, and situated between the Bingera River and the Barricks Creek.

Green-garnet-(Grossularite?) Rock.

This is a dull-green granular rock with a specific gravity of 3·31, which under the microscope is seen to be made up of crystals of a pale-green garnet. These appear to be perfectly isotropic, and show none of the anomalous double-refraction found in some varieties of this mineral. Although many rocks have been described which consist mainly of garnets of different varieties, there is only one, so far as I know, composed mainly of green varieties of the mineral. This is a rock from Dobschau, in Hungary, which has a somewhat different colour and aspect from the rock brought from Bingera. Besides the garnets, which make up the mass of this rock, there are particles of low double-refracting materials between the grains, which are in all probability decomposition products of garnet, like the well-known "kelyphite."

This green-garnet rock of Bingera sometimes contains native gold and also chrysocolla. The rock is now being worked for the gold it contains, yielding about two ounces to the ton. The dyke, which varies in width from 4 feet to 6 inches, has been traced for more than a mile.

Picotite-Rock.

A second dyke, about 2 ft. 6 inches wide, in the mass of serpentine at Bingera is a very dense, well-crystallised black material with a specific gravity of 3·90. Under the microscope it gives the characters of a chrome-spinel, being isotropic and of a rich coffee-brown colour by transmitted light. Professor Wadsworth has pointed out the close analogies between the two spinellids, chromite and picotite, and the frequent transitions between the one mineral and the other. The density and colour of the Bingera mineral lead me to refer it to picotite rather than chromite. The only other mineral associated with the spinellid in the rock is serpentine, which occurs in small quantities.

Picotite is a frequent constituent of lherzolites and other ultrabasic rocks, but I am not aware that any rock, entirely composed of that mineral, has hitherto been described.

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On an Accurate Method of determining the Densities of Solids.

By The Earl of Berkeley, F.G.S.

[Read February 5th, 1895.]

In the course of some researches on the relation between the chemical constitution and the crystalline form of substances, I found it necessary to attempt an accurate determination of the densities of crystals.

Messrs. Playfair and Joule,[1] in 1843, in the course of similar researches, determined the specific gravities of numerous salts by the use of an instrument which showed the actual volume of the solid investigated. This method was found to be subject to many errors, and they abandoned it for one which is the prototype of that ordinarily used in accurate work at present. Their second method[2] consisted in the use of a flask, stoppered by a piece of thermometer tube, which in its turn was covered by a cap, the separate pieces being carefully ground to fit. The thermometer tube was first calibrated, and the capacity of the flask then determined by observing the rise of water in the tube for different temperatures.

After the salt had been introduced into the flask, the latter was filled to a mark while in a bath whose temperature was known, and then was put away to cool before weighing. For salts soluble in water they used turpentine, the specific gravity of which had been determined by the same method.

The only differences between this method and the latest development of it are, that carbon tetrachloride is now substituted for turpentine (except at high temperatures), and that the thermometer tube is replaced by either a perforated stopper or by one ending in a fine capillary, which capillary, while the flask is in the bath, dips under some of the liquid used for the observations.

By means of this process, Mr. Tutton[3]—and I take Mr. Tutton's work

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1 Playfair and Joule, "Relations between Atomic Vols. and S. G.," *Mem. Chem. Soc.*, Vol. II., 1843-45.

2 Playfair and Joule, "Relations between Atomic Vols. and S. G.," *Journ. Chem. Soc.*, Vol. I., 1849.

3 A. E. Tutton, "Crystallography of the Sulphates of Potassium, Rubidium, and Calcium," *Journ. Chem. Soc.*, July, 1894.

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as a type of what accurate work can do with the method—obtained the following results:—

Relative Density at 20° C.

K_2SO_4	Rb_2SO_4	Cs_2SO_4
2·6659	3·6150	4·2411
2·6609	3·6094	4·2458
2·6660	3·6128	4·2433
2·6630	3·6132	4·2459
2·6622	3·6071	4·2432
2·6617	3·6144	4.2412
2·6631	3·6073	

Greatest diff. = ·0051 or ·19 %. ·0079 or ·21 %. ·0048 or ·11 %

The following are the two chief causes of inaccuracy in the use of this method:—

(1.) The loss of liquid through evaporation during the time elapsing between filling in the bath and weighing.

It must be remembered that the most perfect glass-surface contact will not prevent a volatile liquid such as carbon tetrachloride from evaporating. In my own pyknometer the surfaces have been most carefully ground, and I find that 20 grams of the liquid at the ordinary temperature lose ·006 gram in half-an-hour.

(2.) The error due to the differences between the real temperature of the bath, the real temperature of the filled pyknometer, and that shown by the bath thermometer. A difference of ·05° C. makes a difference of ·0013 gram in 20 grams of carbon tetrachloride, and it must be borne in mind that the error may be either a positive or a negative one—hence in comparing any two results it may be doubled—and the results may be still further vitiated by the fact that this difference, or the error due to it, is also involved in the determination of the density of the carbon tetrachloride and in the calculation for the capacity of the flask.

However, Mr. Tutton partly overcomes this by determining the density of the carbon tetrachloride anew every time he determines that of the solid—that is, the bath heats two flasks, one containing the liquid and salt, the other the liquid only. This, on the assumption that the flasks are equally heated, leaves only the error due to the discrepancy between the true bath temperature and that shown by the bath thermometer. In the following method no error due to the evaporation of the liquid is involved, indeed this evaporation is actually an essential of the method.

I obtained a pyknometer having a thermometer stopper and a capillary

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(closed by a cap) at the side—there is in principle nothing new about it, and the article in a rough form is sold by all chemical apparatus manufacturers. Having tried several pyknometers of various sizes, I found the following, which was made by Dr. Geisler of Bonn, to my instructions, to be the best:—

The thermometer stopper is graduated from 10° C. to 20° C. to $\frac{1}{10}°$, and of such a length that the $\frac{1}{100}°$ can be estimated, and the capacity is about 12 cc. The latter is reduced to the lowest limits compatible with accuracy, so that a smaller quantity of salt will suffice; and this is of great importance in the case of salts such as Cs_2PtCl_6, which are difficult to obtain well crystallised in large quantities. The form is cylindrical, and is preferred to the spherical because of its relatively larger surface enabling it to take up more rapidly the temperature of the balance case.

I may here mention that I am having a conical shaped pyknometer made, from which I hope to obtain some advantages in the practical manipulation of the apparatus.

The method of procedure is as follows:—

After the thermometer has been compared with a standard, the pyknometer is weighed against another one as closely similar as possible, which is used as a counterpoise throughout the observations. This is necessary for two reasons. First, to insure that the error in weight due to the deposition of moisture on the glass is negligible; secondly, to do away with the correction for the air displaced by the glass of the pyknometer. The capacity of the pyknometer at different temperatures is then determined by weighing it when filled to the mark with pure water (freed from air and CO_2), and noting the temperature of the water at the instant of weighing. As the evaporation of the water is not rapid enough to cause its level to coincide with the mark within a reasonable time, it was found necessary for this purpose to fall back upon the contraction and expansion of the liquid; and to obviate any error due to the "lag" of the thermometer, two series of weighings at different temperatures were obtained—one when the pyknometer had been filled above the mark with water slightly warmer than the balance case, and the other with it filled below the mark with water colder than the case. In the first series the weighings and temperatures were taken when the contracting water brought the level and mark into coincidence; and in the second, when the expanding water did the same. Then by rejecting all observations in which the contraction or expansion was rapid, *i.e.* all observations in which less than half-an-hour had elapsed between placing in the balance case and weighing, and by taking the means of the weighings obtained

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from contracting and expanding water at about the same temperatures, it was hoped the error for "lag" could be neglected.

The results obtained are :—

12·2880 grams at 12°·03 C.
12·2861 ,, ,, 13°·03.
12·2821 ,, ,, 16°·05.

These, when corrected for the density of water at the respective temperatures, give the capacity of the pyknometer at those temperatures : —

12·2933 cc. at 12°·03.
12·2935 ,, ,, 13°·03.
12·2942 ,, ,, 16°·05.

From which the expansion of the pyknometer for intermediate temperatures can be found. Having obtained these constants, the relative density of the CCl_4 used is determined by filling the pyknometer above the mark, and waiting until the CCl_4 *evaporates* down to the mark, and then weighing and observing the temperature at the same time.

The following numbers were obtained for the weight of 12·2940 cc. of the carbon tetrachloride used :—

19·8048	grams at	11°·17 C.	19·7350	grams at	14°·07 C.
19·7956	,,	11°·59 ,,	19·7339	,,	14°·11 ,,
19·7744	,,	12°·32 ,,	19·7201	,,	14°·70 ,,
19·7713	,,	12°·84 ,,	19·7169	,,	14°·84 ,,
19·7666	,,	12°·78 ,,	19·6898	,,	15°·64 ,,
19·7548	,,	13°·21 ,,	19·6610	,,	17°·33 ,,
19·7459	,,	13°·62 ,,	19·6480	,,	18°·18 ,,
19·7408	,,	13°·84 ,,		...	

and from these a curve was drawn by the use of which the weight at intermediate temperatures could be estimated.

The density of the salt is determined in a similar manner. A known weight of the powdered crystals is placed in the pyknometer, and just covered by CCl_4, and the whole put under the receiver of an air pump, which is exhausted until no more bubbles of air come from the salt. The pyknometer is then filled above the mark with CCl_4 and weighed as before.

The following results were obtained :—

K_2PtCl_6	Cs_2PtCl_6	Rb—alum.
3·4711 at 14°·13 C.	4·1930 at 18°92 C.	1·8853 at 18°·91 C.
3·4695 ,, 15°·08 ,,	4·1926 ,, 13°·79 ,,	1·8852 ,, 14°·16 ,,
3·4698 ,, 14°·43 ,,	4·1940 ,, 13°·56 ,,	1·8849 ,, 14°·17 ,,
...	...	1·8858 ,, 13°·61 ,,
Greatest diff. 0·0016	0·0014	0·0009
Percentage diff. 0·041 %	0·033 %	0·047 %

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All observations are corrected for air displaced by the liquid and the weights. Also all observations in which the level of the liquid passed the mark before half-an-hour had elapsed between placing on the balance and weighing were rejected, and so were those in which the temperature of the liquid and that of the balance case differed by more than $\frac{1}{5}$° C.

To avoid any error due to the film of air which adheres to the inside of the glass vessel, the pyknometer was, after careful washing with water, always rinsed out three times with pure alcohol and dried.

Each separate density given above was made on a different crop of crystals; and hence the probability is that the slight disagreements in the results obtained are not due so much to the method employed, but to different states of hydration of the salt or to slight differences in the amount of residual air adhering to the powder, or perhaps to real differences in the density of the different crops of the same crystals. Therefore the method may be considered to give the density of any given sample to an accuracy of $\frac{1}{2000}$.

May I perhaps point out to mineralogists the importance of accurate density measurements? Although minerals are, as a rule, impure, yet if several accurate determinations of the densities of different specimens of the same mineral have been obtained, and if the chemical composition of the specimens are known, then it is quite possible to calculate the density of the pure substance, and the knowledge of this constant is of the utmost importance for any theoretical dealing with crystals, the more so in that the majority of minerals cannot be produced artificially.

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Enargite.

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[Read April 2nd, 1895.]

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The following is a complete *list of the forms* of enargite; those present on the British Museum specimens are indicated by one asterisk, while new forms are indicated by two. The letters are those used by Dana (*Min.*, 6th Ed.) and Goldschmidt (*Index der Krystallformen*, I., 551, 1886).

* *a* 100. Usually large and roughly striated vertically; rarely horizontally (Coquimbo).

* *b* 010. Recorded by most authors, but on the Museum specimens very rare as a face of any size, being generally only detected by the goniometer, and then not frequently.

* *c* 001. Usually large and bright with faint, or sometimes deep, striæ parallel to the macrodiagonal; rarely parallel to the brachydiagonal (Coquimbo).

** *y* 610. Doubtful, only observed by means of the δ-eyepiece of the Fuess goniometer: (Famatina).

* *r* 310. p^3 of Rammelsberg. Bright and narrow, fairly common.

** *f* 520. Bright and narrow, on two crystals from Willis Gulch, Colorado.

* *d* 210. p^2 of Rammelsberg, *v* of Pirsson. Bright and narrow, fairly common.

x 820. Twin plane, not a recorded form; some very doubtful measurements seem to indicate its presence.

** *i* 540. Narrow: Luzon and Colorado.

* *m* 110. *g* of Dauber and Goldschmidt, *p* of Rammelsberg. Usually large, often deeply striated vertically; rarely horizontally (Coquimbo).

** *N* 230. Narrow: Silverton, Colorado, also Willis Gulch.

* *h* 120. *n* of vom Rath. Bright and narrow, common.

* *l* 130. Bright and narrow, often present.

** *t* 108. Narrow: Famatina.

** *A* 207. Narrow: Famatina and Luzon.

* λ 103. Bright and narrow, not common: Famatina and Luzon.

* *n* 102. Bright and narrow, fairly common.

** *w* 709. Narrow: Parád, Hungary.

* *k* 101. Bright, often fairly large, common.

e 403. (Dauber?). This is given by Goldschmidt as 084 instead of 304.

* *μ* 201. *m* of Dauber and Goldschmidt. Very narrow: Famatina.

** *u* 801. Large and bright, somewhat rounded, and striated horizontally: Famatina. This is probably the steep dome mentioned by Stelzner (*l. c.* p. 241).

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** *B* 601. Doubtful, only observed with δ-eyepiece: Famatina.
E 012. *e* of Pirsson.
* *s* 011. Small and bright, not frequent.
** *K* 054. Large and rough, striated parallel to the brachydiagonal Willis Gulch.
θ 051. (Zettler).
q 115. (Zepharovich). Scattered images were observed about this position; also scattered images near the positions of (113) and (114), but very doubtful; these were only present on two Famatina crystals as rough, narrow roundings.
p 112. (Dauber).
o 111. (Dauber and Zettler).
L 132. (Dauber ?).
x 134. (Pirsson).

The following table gives the measurements establishing the new forms:—

	Measured.	Limits.	No.	Calculated from *mm* 82°0½′ and *ck* 43°42′.
a : *y* 610	8° 38′	..	..	8° 14½′
f 520	19 4½	18°56′ —19° 47′	5	19 11
i 540	34 22	34 17 —34½	2	34 49
N 230	52 28	51 0 —54¼	4	52 31
c : *t* 108	6 42	6 38 — 6 46	2	6 49
A 207	14 58	..	..	15 16½
w 709	36 18	36 0½—36 25	2	36 38
u 301	71 12	70 46 —71 44	3	70 46
B 601	80 1	..	..	80 6½
K 054	45 47	..	..	46 5

Owing to the striated nature of faces in the prism zone, and of the macrodomes, few of the measurements are really good, while the reflections from the cleavage surfaces are often somewhat blurred; nevertheless, from the results obtained by the measurement of forty crystals and cleavage fragments, it would seem that the value of the prism angle (*mm*) of 82° 7′, as given by Dauber, is somewhat too high. The measurements of this angle gave the following results:—

82°0½′ mean of 26 best, from crystal faces; limits 81°17′—82°34′
82°0′ ,, ,, 11 ,, ,, cleavages; ,, 81°46′—82°16′
82°1′ ,, ,, 128, all measurements; ,, 80°32′—82°39½′
82°0′ ,, ,, 10, cleavages of "clarite"; ,, 81°10′—82°45′

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Also the published measurements for this angle are all lower than that given by Dauber. Breithaupt gives 81°49¼′ as the mean of his measurements of the cleavage angle, with the remark that the error cannot be more than one minute. Rammelsberg gives 81°50′ and 82°15′; v. Pettko and v. Kobell both give 82°; Neufville 82°2′ as the mean of several cleavage angles, with a variation of 3′. The means of those given by other authors are :—

	Dauber.	v. Zepharovich.	Pirsson.	L. J. S.		
				Mean.	Limits.	No.
mm, 110 : 1$\bar{1}$0	*82° 7½′	81° 48′	81° 52½′	*82° 0½′	See above.	
ck, 001 : 101	43 39	43 32	43 1	*43 42	42°55′—44°19′	14
cs, 001 : 011	*39 31	39 31	39 24½	39 42½	39 39— 39 45	3

Both 43° 42′ and 39° 42½′ are good measurements, and *cs* is calculated from 43° 42′ and 82° 0½′ as 39° 43¼′, this agreeing very closely with the observed angle. These angles (*mm* and *ck*) give the parameters :—

$$a : b : c = 0{\cdot}8694 : 1 : 0{\cdot}8308.$$

Dauber's measured angles for *ck*, *cp*, *cn* and *co* are much nearer to the angles calculated from these parameters than to those calculated from his own (0·8711:1:0·8248); but his determination of *cs*, which is the mean of five angles, with variation of only 7′, and v. Zepharovich's measurement of the same angle, seem to indicate that there is not the same justification in attaching a new value to the *c* axis as to the *a* axis.

Habits.—All the crystals examined were elongated in the direction of the prism zone, and terminated at the unattached end by the bright basal plane; most of them consisted only of the forms *a*, *m* and *c*, forming a six-sided prism. The forms *a* and *m* are usually equally developed, but sometimes *a* is small or absent, or at times it is large, giving rise to tabular crystals. Other prism forms are only present as narrow faces. Domal forms, of which *k* is the most common, are comparatively rare, and are usually present as narrow faces, rarely influencing the habit of the crystals by excluding the basal plane; *k*, however, often seems to be developed as a large face on crystals from Luzon. In no case was a definite pyramid face observed.

Twinning.—The only mode of twinning which has been detected on the Museum specimens is that first described by vom Rath, in which the horizontal axes (*a* and *b*) of the different individuals cross each other at

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approximately 60°, as in the twins of chalcocite, aragonite, chrysoberyl, &c. Such twins are frequent on specimens from Parád (Hungary) and Famatina (Argentina), and on "clarite" from Schapbach (Baden), but seem to be rare from other localities; only a single crystal, consisting of two individuals, having been noticed on any of the other specimens (Coquimbo). Zettler, however, mentions twins from Luzon, for which he gives the twin plane as $x(820)$ in preference to $h(120)$.[1] The twin crystals nearly always show only the c and m faces with sometimes narrow h and a planes, but apparently never any of the domes, though these are often present on the simple crystals. The basal planes of the different individuals form together one large bright plane, on which, according to vom Rath's figure, are to be seen the traces of the planes of combination. Such has, however, not been observed on the Museum specimens, and the twins examined appear rather to be of the nature of interpenetration twins. The following angles were those observed between the m faces in going round the prism zone of a twin crystal from Parád, consisting of three individuals, with very bright prism faces. The angles are calculated from mm 82° 0½′ (82° 0′ was the mean of the observed angles on this crystal); the twin planes being inclined to each other.

Measured.	Calculated twin plane x (320).	Calculated twin plane h (120).
38° 26′	38° 23½′	38° 11½′
21 31	21 48½	22 12½
37 46	37 47½	37 35½
22 19	22 24½	22 12½
37 47	37 47½	38 11½
60 25	60 12	59 48½
21 47	21 48½	22 12½
59 42½	59 36	59 48½

The magnitudes of the measured angles, as well as the order in which they occur, thus show that $x(820)$ and not $h(120)$ is the twin plane. G. vom Rath gave x as the twin plane and plane of combination, but remarked that h could be equally well taken as such (the plane of combination being perpendicular thereto), as the striated nature of the prism zone rendered it impossible to distinguish between the two by measurement. The non-existence of the twin plane x as a crystal-form is remarkable.

[1] The twin crystals from Brixlegg (Dana, *Min.*, 6th ed.) are not mentioned by v. Zepharovich.

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Twinning on the *m* (110) plane has been mentioned, but contradicted by vom Rath. J. v. Pettko says that staurolite-like twins occur at Parád; if these resemble the staurolite twins which have the individuals crossing at approximately 60°, they would probably be the ordinary *x* twins of enargite. Groth mentions as doubtful, twins on a macrodome on crystals from Emma mine, Utah.

Parallel growth (?) *of Enargite and Barytes.*—On a macropinacoid face of a crystal of enargite from Famatina was a minute tabular crystal of barytes, the basal planes of the two minerals reflecting light together, and as far as could be judged by the eye the prism planes (which have about the same cleavage angle) were parallel. The *a*, *b* and *c* axes of the two minerals are therefore respectively parallel. This was, however, only once observed, although on some specimens there were many crystals of barytes.

THE IDENTITY OF "CLARITE" WITH ENARGITE.

A specimen in the British Museum labelled "Clarit, Schapbach, Baden, 1874," was examined, and seen to consist of radiating bushy groups of earthy, bluish covellite containing bright specks of copper pyrites; only very little of the original mineral, after which the covellite is pseudomorphous, was present; this showed bright cleavage surfaces, and had all the appearance of enargite. The specimen thus agrees with the description given by F. Sandberger (*Neues Jahrb. Min.*, 960, 1874; 382, 1875) of the mode of occurrence and alteration of "clarite."

Eight small cleavage fragments of the fresh mineral were measured on the goniometer, the images not being good, the δ-eyepiece of the Fuess instrument had to be used. Generally two or three large cleavage surfaces were present, while all round the zone were many (sometimes 8 or 9) small bright cleavages, apparently belonging to small individuals intergrown in twin position in the main crystal. These cleavages corresponded in position to the perfect *m* cleavage of enargite, a less perfect one being at the position of *a*, while *b* was not observed. In the following table, the calculated angles are those which exist between the *m* cleavages when the crystals II. and III. are twinned on the two *x*(320) planes of the crystal I. respectively, the angle *mm* being taken as 82°0½'.

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	Calculated.	Measured.	Limits.	No.
$m_I\ m_{II}$	37° 47½′	37° 39′	37° 17′–38° 3′	7
,,	21 48½	21 38	20 57—22 13	10
$m_{II}\ m_{III}$	38 23½	38 28	37 47—39½	8
,,	22 24½	22 38	22½ —23½	9
$m\ m$	82 0½	82 0	81 10—82 45	10

The measured angles agree better with the calculated angles when x (320) is taken as the twin plane, than when h (120) is taken, and when III is twinned on I instead of on II. The measurement of these fragments thus not only shows that "clarite" is identical with enargite, but indicates that x (320) is to be taken as the twin plane in preference to h (120), a point which was left as somewhat doubtful by vom Rath.

Sandberger mentions in his paper that after much trouble he succeeded in isolating an imperfect crystal which had an end face (0P) steeply inclined to the prism zone, and showed a perfect cleavage ($\infty \breve{P} \infty$) and a less perfect one ($\infty \breve{P} \infty$) perpendicular to the last. This crystal was too much altered on the surface for measurement, and not even the cleavage angle could be determined on the goniometer. It is mentioned that the crystal resembles the figures given by Zepharovich for the oblique freieslebenite[1]; these figures, however, refer to rhombic diaphorite and not to freieslebenite. From the above data he concluded that the crystal was oblique, and not rhombic, as he at first thought[2]; they do not, however, appear to afford sufficient grounds for this conclusion, as the two pinacoid cleavages of a rhombic crystal would naturally show different degrees of perfection, while the end face, which is a dome in Zepharovich's figures, may be one face of the dome developed to the exclusion of the basal plane of a rhombic crystal and of the other face of the dome; such has been observed in the case of the form k (101) on crystals of enargite from Parád, Hungary. This position of the crystal would, however, not agree with the perfect m cleavage of enargite. The end face may then possibly have been one face of a pyramid (pyramidal forms seem, however, to be rare on enargite), and the cleavages may have been the m cleavage of enargite with an angle of 82°, in which case $\infty \breve{P} \infty$, $\infty \breve{P} \infty$, ∞P, 0P of Sandberger would correspond to m, m, a and b, and a pyramid face respectively.

The only other points of distinction emphasised are, the dark lead-gray

[1] *Ber. Ak. Wien*, LXIII., I., 1871, Pl. II., Figs. 6 and 7.

[2] *Neues Jahrb. Min.*, 960, 1874.

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colour, this is, however, called dark steel-gray in the preliminary notice (*Neues Jahrb. Min.*, 960, 1874); and the hardness of 3·5 instead of 3: the density and composition being the same as those of enargite. In the preliminary notice it is stated that copper, antimony, arsenic and sulphur were detected qualitatively, with the remark that such a combination of elements is only known in fahlerz; such, however, is not the case, nor was it in 1874. It was apparently on these grounds that the name was in the first instance given, as the mineral was then said to be apparently rhombic.

Several other minerals, with a composition similar to that of enargite, have at one time and another been described. Of these, guayacanite and garbyite are mere synonyms of enargite, the names having been withdrawn by their authors. *Luzonite*,[1] however, from its absence of cleavage and its reddish colour, seems to differ from enargite, though its chemical composition and density are the same. The first mention of this mineral was made by Zerrenner[2] ("brauner Kies"); and it was stated by F. W. Fritzsche,[3] who made a qualitative analysis of it, to be massive dufrenoysite (binnite of Des Cloizeaux). Two[4] of the three analyses that have been made of *binnite* agree with the enargite formula, though the earliest,[5] which is the one usually accepted, does not. The mineral also shows an absence of cleavage, and has a brownish colour on the fractured surfaces. Moreover, as it has the same density as luzonite, these two minerals may possibly be identical, luzonite being the massive form of binnite.

A. D'Achiardi's *regnolite*,[6] which was first described as occurring in isometric tetrahedra resembling sandbergerite, and having a composition somewhat similar to enargite, may possibly be referred to binnite, though the composition is not in close agreement.

The isodimorphous series as given by F. Klockmann[7] would then become:—

Cu_3AsS_4, Enargite, rhombic	Binnite (and Luzonite), cubic.
Cu_3SbS_4, unknown	Famatinite do. (?).

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[1] A. Weisbach, *Min. Mitth.*, 257, 1874.
Berg-Hütt. Ztg., 106, 1869.

[2] *Berg-Hütt. Ztg.*, 438, 1869.

[4] Stocker-Escher, *Kenngott's Uebers.* 1856-7, 174, 1859; R. W. E. Macivor, *Chem. News*, XXX., 103, 1874.

[5] Uhrlaub, *Pogg. Ann.*, XCIV., 115, 1855.

[6] *Il Nuovo Cimento*, 314, 1870; *I Metalli*, I., 293, 294, 1883.
Zeits. Kryst., XIX., 274, 891; cf. Abst., *Min. Mag.*, X., 337, 1894.

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Enargite usually contains no, or only one or two per cent. of antimony, but the three published analyses with six per cent. (Root, Domeyko, and E. Bittsanszky quoted by v. Pettko) show a transition of enargite towards the unknown member of the series, while the famatinite analysed by Frenzel[1] is half way between binnite and famatinite.

Frenzel's *lautite* has been considered by Weisbach to be a mechanical mixture of native arsenic with a sulpho-salt near enargite. It is therefore placed by Dana[2] under enargite, though it is not placed in such a position by Groth.[3] The specimens from Lauta, Marienberg, Saxony, were examined, and on the bright cleavage surfaces could be seen no trace of the native arsenic mentioned by Weisbach, the substance having all the appearance of a definite mineral. One perfect cleavage is present giving rise to a platy separation of the mineral. There are also two or more other less perfect cleavages, which give scattered images, and on the goniometer no consistent measurements could be obtained; but none of the angles, on the several fragments measured, agreed with those of enargite.

Localities of Enargite.—A complete list not having been before compiled, the following may be of use:—

Saxony.—Junge hohe Birke mine, Freiberg? (Breithaupt, *Pogg. Ann.*, LXXX., 386, 1850; not confirmed).

Baden.—Clara mine, Schapbach ("Clarite").

Silesia.—Kupferberg? (H. Fiedler, *Min. Schlesiens*, 1868).

Tyrol.—Matzenköpfl, Brixlegg.

Hungary (Matra Mts.).—Gabe Gottes mine and Katharina mine, near Parád; Recsk.

Philippine Islands.—Mancayan, District Lepanto, Luzon.

Colorado.—Gilpin Co.—Mines near Black Hawk (Willis Gulch) and Central City; Russel Gulch, particularly Power's mine.

Rio Grande Co.—Ida mine, Summit District.

San Juan Co.—National Belle mine, Red Mtn.; Silverton (from a label in the British Museum).

Park Co.—Missouri mine.

Utah.—Juab Co. (Tintic District)—Copperopolis mine (American Eagle mine) and Mammoth mine.

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[1] *Neues Jahrb. Min.*, 679, 1875.

[2] *Min.*, 6th Ed.
Tab. Uebers. Min., 3rd ed.

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Millard Co.—Shoebridge mine; Dragon mine.

Salt Lake Co.—Emma mine; Oxford and Geneva mine.

Montana.—Silver Bow Co.—Several mines near Butte (Liquidator, Gagnon, Parrot, Colusa).

Lewis and Clarke Co.—Marysville (*Min. Mag.* VI., 124).

Missoula Co.—Bell and Stow mine.

South Carolina.—Chesterfield Co.—Brewer's mine.

California.—Alpine Co.—Morning Star mine; Stella mine.

Mexico.—Milpillas, Chihuahua [on A. del Castillo's mining map of Mexico this is Minillas].

Peru.—Prov. Junin: Morococha, Tarma (San Francisco mine and mine of Señor de la Carcel); Cerro-de-Pasco.

Cajamarca: Comotera mine, Cajabamba.

Chili.—Prov. Coquimbo: Hediondas mine, Elqui (this, according to Domeyko, is the locality for Field's "guayacanite"; it is not far from the smelting works after which the name is given).

Santiago: San-Pedro-Nolasco mines.

Atacama: Cerro Blanco mines.

Mine de la Ung (from a label in the British Museum).

Columbia, S. A.—Mines of Santa Anna.

Argentina.—Prov. La Rioja: Several mines in the Sierra Mejicana, Sierra Famatina (*e.g.* Upulungos, Mejicana, Verdiona, Anduesa, San Pedro Alcántara, Compañia, Coquimbana, &c.).

Catamarca: Capillitas.

San Juan: Guachi.

New South Wales.—(A. Liversidge, Minerals of N. S. Wales, 62, 1888; Catalogue of Minerals in the Australian Museum, Sydney, 1885).

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Lewisite and Zirkelite, two new Brazilian Minerals.

By Dr. E. Hussak,
Of the Geological Survey of S. Paulo,

AND

G. T. Prior, M.A., F.G.S.
Assistant in the Mineral Department of the British Museum.

[Read June 18th, 1895.]

I. Lewisite.

THIS new antimonate was found in the cinnabar mine of Tripuhy, near Ouro Preto, Minas Geraes, Brazil.

The occurrence of cinnabar at this locality has been known since 1810, and a short notice of it is given by Eschwege in his *Pluto Brasilensis*, p. 456, which was published in 1833.

Some three years ago work of a prospecting character was undertaken by the Companhia Mineralogica under the direction of the mining engineer, F. P. de Oliverra, and, by his invitation, one of us had an opportunity of examining the locality and making a collection of its minerals. The cinnabar, which had previously only been known to occur in rolled fragments up to the size of a pea, was found in small quartz veins, in a metamorphic mica-schist.

The small hill, to which the cinnabar is confined, consists of argillaceous mica-schist passing into hæmatite-mica-schist (itabirite): in places the rock contains much iron-pyrites altered to limonite, and is cut by a dyke a few metres wide of diabase-porphyrite. The slope of the hill is covered with a thick bed of gravel containing numerous fragments of cinnabar up to the size of a fist. This gravel, on washing with the batea, affords a residue of fine heavy sand consisting mainly of cinnabar and specular iron, but containing also a variety of other interesting minerals.

Lewisite is one of the minerals found in this heavy sand.

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Physical Characters.

The mineral is cubic, and occurs in small (seldom exceeding a millimetre in greatest diameter) perfect octahedra without modification. A measurement of the octahedral angle gave 109° 22′. Twinning according to (111) is rare. The mineral is isotropic, and has a fairly perfect octahedral cleavage.

Colour, honey-yellow to colophony brown; streak, light yellowish-brown; translucent; lustre, vitreous to resinous.

Hardness, 5·5; not brittle.

Density (weight of 1 cc.), 4·950 at 18° C., as determined on 0·9784 gr.

Under the microscope some of the crystals were seen to be filled with small, colourless, doubly-refracting grains and scales of mica, extending in part beyond the crystal faces, and also with exceedingly fine yellow needles (rutile ?) and isolated gas pores.

Occasionally the crystals show a thin, sulphur yellow, pulverulent decomposition crust, and the same alteration product may be seen on the cleavage surfaces and in cavities in the centre of the crystals.

Chemical Characters.

In the Bunsen flame the mineral fuses somewhat readily on the edges, and gives a greenish-blue colour to the flame. The microcosmic bead in the reducing flame is yellow while hot, violet when cold. The mineral is insoluble in acids, is decomposed by fusion with sodium carbonate, and is easily reduced by heating to low redness in hydrogen.

Method of Analysis.

The analysis was made on material freed as far as possible by careful selection under the lens from crystals showing alteration or inclusions.

The finely-powdered mineral, dried at 110°, was reduced in a current of hydrogen. No fluorine could be detected in the sodium carbonate plug which was placed at the end of the combustion tube. The material after reduction was digested in aqua regia, to which tartaric acid was added, and the solution was filtered off from some insoluble siliceous impurity (6·37 per cent.), the weight of which in the calculation of the analysis was deducted from the weight of material taken. The antimony was precipitated by sulphuretted hydrogen, and weighed as black sulphide after heating in carbonic acid. After weighing, the precipitate was fused with sodium carbonate and sulphur, and a little titanic acid was separated. No lead could be detected. The filtrate from the sulphide of antimony was made alkaline with ammonia, and a portion of the calcium which came down as tartrate was collected, ignited, re-dissolved, and finally

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precipitated by ammonium oxalate. The iron and manganese were precipitated by ammonium sulphide, and the titanium, after the destruction of the tartaric acid, by a double precipitation with ammonia. In the filtrate the calcium and alkalies were determined in the usual way. 0·0982 gr. of the mineral was tested for fluorine by fusing with sodium carbonate and finally precipitating with calcium chloride. The precipitate dissolved to a clear solution in water acidified with acetic acid; and although a very slight residue, insoluble in water, was obtained on evaporating to dryness and treating with water, no fluorine could be detected in it by the microchemical barium silico-fluoride test.

Result of Analysis.

	I.	II.	Calculated for $5CaO, 3Sb_2O_5, 2TiO_2$ III.
Sb_2O_5	67·52	65·52	68·42
TiO_2	11·35	11·70	11·70
CaO	15·93	15·47	19·88
FeO	4·55	6·79	—
MnO	0·38	—	—
Na_2O	0·99	1·06	—
	100·72	100·54	100·00

Analysis I. was made on 0·5429 gr. of material dried at 110°.

Under II. is given the result of a preliminary analysis made on 0·2259 gr. of a different sample of material, which had been ignited.

The numbers under I. correspond approximately to the formula 5RO, $3Sb_2O_5$, $2TiO_2$, or 3(RO, Sb_2O_5), 2(RO, TiO_2), the calculated percentages for which are given under III.

The mineral is thus a titano-antimonate of calcium and iron, related on the one side to the calcium titanate perofskite, and on the other to the calcium antimonates atopite and romeite; it may also be said to be connected with the pyrochlore group of minerals, with antimonic acid replacing niobic acid.

At the time when the above analyses were made, no mineral of similar composition had been described, but in the last number of the Journal of the Geological Society of Stockholm (*Geol. Fören. Förhand. Stockholm*, XVII. (1895), pp. 313-18) there appears an account by Prof. H. Sjögren of what proves to be a very closely allied mineral, a new titano-antimonate from Jakobsberg, to which he has given the name Mauzeliite. It is iso-

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metric, of brown colour, with specific gravity 5·11, and has the following chemical composition :—

Sb_2O_5	...	...	59·25
TiO_2	...	...	7·93
PbO	...	...	6·79
FeO	...	...	0·79
MnO	...	...	1·27
CaO	...	...	17·97
MgO	...	...	0·11
K_2O	...	...	0·22
Na_2O	...	...	2·70
H_2O	...	. .	0·87
F	...	...	[3·63]
			101·53
−O for F			1·53
			100

The composition of the two minerals is thus very similar, but the larger amount of iron and the absence of lead and fluorine serve to distinguish the Brazilian mineral from the Mauzeliite.

We have given the name of Lewisite to this new titano-antimonate from Brazil in honour of Prof. W. J. Lewis, during whose tenure of office the study of Mineralogy in the University of Cambridge has been so much encouraged.

Besides the Lewisite, in the heavy sand derived from the washing of the gravel from the small hill at Tripuhy were found the following minerals :—

(1.) Xenotime occurring sparingly in elongated prismatic crystals from 2 to 3 mm. in length, showing the combination {110} and {111}, and more rarely extremely small and narrow faces {331} and {311}. The crystals are translucent and of wine-yellow colour, and have a very distinct prismatic cleavage. A measurement on one of the crystals of the pyramid angle $(111 : \bar{1}11)$ gave 82° 12′.

In form and appearance the xenotime crystals strongly resemble those of the diamond sand of Dattas, near Diamantina.

(2.) Monazite is fairly abundant in light sulphur-yellow and yellowish-brown crystals, from 1 to 2 mm. in length. Two types of crystalline

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form were distinguished: (*a*) tabular parallel to *a*(100), resembling turnerite, of yellowish brown colour, completely transparent, and free from inclusions; (*b*) prismatic by extension of *v*($\bar{1}11$), like the crystals from Alexander Co., N.C., of sulphur-yellow colour, and rich in inclusions of magnetite grains.

The following angles were measured on these crystals:—

	(*a*.) Turnerite type.		(*b*.) Alexander Co. type.
	Measured.	Calculated (Des Cloizeaux).[1]	
al	25° 4′	25° 14′	...
an	61° 38′	62° 4′	...
bn	28° 36′	27° 56′	...
bv	54° 2′	53° 22′	...
bu	30° 6′	29° 11′	...
be	48° 31′	48° 10′	...
ar	49° 16′	48° 3′	...
ae	80° 58′	79° 47′	...
av	61° 34′	61° 41′	61° 30′
ac	80° 24′	79° 47′	...
aw	39° 22′	39° 17′	39° 17½′
vv	...	73° 16′	73° 11′

The letters are those used in *Dana's Mineralogy* (6th ed.), p. 750, figs. 3-7.

Of the crystals of the turnerite type, only one very rich in faces was found suitable for measurement, and this, in spite of its favourable appearance, gave, on account of the imperfect development of the faces, great variations in the angles. This crystal showed the combination: *a*(100) predominant, *b*(010) tolerably broad faces, *n*(120), *l*(210), *v*($\bar{1}11$), *r*(111), *e*(011), *u* (021), *w*(101), *x*($\bar{1}01$). The sulphur-yellow crystals of the Alexander Co. type were very poor in faces, appearing for the most part as monosymmetric prisms with end-faces of the combination *v*($\bar{1}11$) and *a*(100). Other combinations observed were: *v*, *a*, *w*: *v*, *a*, *w*, *x*: *v*, *a*, *w*, *x*, *b*.

(3.) Zircon: very rare, in small prismatic crystals of a wine-yellow colour.

(4.) Kyanite: very abundant, in transparent colourless to dark grey tabular crystals of the thickness of a sheet of paper. The crystals often become opaque from included grains. Of especial interest is the not in-

[1] *Man. Min.*, II., p. 472.

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frequent occurrence of geniculated contact- and penetration-twins, precisely agreeing with those first described by Kenngott, and later by M. Bauer, with the face $y(\bar{1}\bar{2}1)$ as twinning plane. Measurements of the angle $M:M$ on three crystals gave 62° 46′ to 62° 56′, agreeing very closely with the value calculated by Bauer. (Compare also Hintze, *Mineralogie*, p. 160, fig. 63.)

(5.) Tourmaline: rare, in microscopic dark brown prisms, mostly broken.

(6.) Rutile: tolerably abundant, in prismatic crystals from 1-3 mm. in length, for the most part tabular parallel to one of the prism faces, and then also often with two faces of the pyramid $s(111)$ prominently developed, so as to give an apparently monosymmetric character. The minute crystals are very rich in faces; the observed forms were: $a(100)$, $m(110)$, $l(310)$, $s(111)$, $e(101)$, $t(313)$; twinning, according to $e(101)$ and $v(301)$, very frequent.

(7.) Hæmatite: with quartz and muscovite forms the principal part of the heavy residue of the gravel. Well formed crystals of the combinations c, r, n, and c, m, a occur, and show a distinct polysynthetic twinning striation according to r, along which the crystals part readily.

(8.) Iron-pyrites: tolerably abundant, in crystals rarely exceeding a millimetre in greatest diameter, and always altered to dark brown limonite. The crystals show the combination $e(210)$, $a(100)$, $o(111)$.

(9.) Magnetite: very abundant, in very small octahedral crystals, rarely altered to martite.

(10.) Gold: very rare, in thin compressed flakes.

(11.) Finally, from this locality we have a new titano-antimonate of iron, the composition of which has not yet been accurately determined owing to lack of material.

The mineral occurs in extremely slender and very fragile hexagonal prisms, about 2 mm. long, of a resinous black colour, on which as terminal faces only the base has thus far been observed, since the slender needles are almost invariably broken and show a conchoidal fracture.

The crystals appear to be rhombic, the mean of several measurements of the remarkably lustrous prism faces over (010) being 91° 58½′. In combination with the prism is almost always the macropinacoid $\{100\}$, parallel to which the crystals are often tabularly developed. The rare basal face is arched and rough, so that no measurements could be made.

On account of the friability of the mineral, no optically orientated sections could be prepared, so that the reference to the rhombic system is not beyond doubt. In thin splinters the mineral is translucent, with a

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dark brown colour; it is optically biaxial, with strong double refraction. It has a well developed conchoidal fracture without distinct cleavage. A rare twinning intergrowth according to a brachydome face, by which two prisms flattened along $a(100)$ cross at an angle of $60\frac{1}{2}°$ (measured under the microscope), is noteworthy. The density (weight of 1 cc.) was 4·529 at 22° C. as determined on 0·1121 gr.

The result of a qualitative and partially quantitative analysis, made on 0·0761 gr. of material, showed the presence of oxide of antimony with FeO (about 40 per cent.) and TiO_2 (about 17 per cent.).

Of the above minerals, the three first, xenotime, monazite and zircon, presumably come from rocks of a granitic character, for O. A. Derby (*Am. Jour. Sci.* XXXVII. p. 109 and XLI., p. 308) has shown that these minerals, particularly xenotime and monazite, are very characteristic of certain types of granite.

A search for exposures of granite in the vicinity, however, proved fruitless.

The other minerals are undoubtedly derived from the argillaceous mica-schist which passes into itabirite.

The state of preservation of the above minerals from the gravel warrants the conclusion that they have not suffered long transportation, but have been deposited close to their place of origin as the gravel, derived from the weathering of the schist and the included quartz veins, was formed. The crystalline form of all is well preserved, even the cinnabar fragments presenting sharp angles. The Lewisite probably comes, like the cinnabar and gold, from the quartz veins.

The occurrence of antimonates with gold has already been observed by Dr. J. C. da Costa Sena at Sao Bartholomeu, near Ouro Preto, only a few miles distant from Tripuhy.

II. ZIRKELITE.

A new calcium zirconate and titanate.

This mineral was found with baddeleyite, perofskite, etc., in the decomposed magnetite-pyroxenite of Jacupiranga, S. Paulo, Brazil.

A brief preliminary notice of it has already been given by one of us in a paper describing the new zirconia mineral baddeleyite and its associated minerals (*Tschermak's Min. u. Pet. Mitth.* XIV. pp. 408-10).

Physical Characters.

Crystal system, cubic, the only observed form being $o(111)$. The crystals are always flattened parallel to an octahedral face, and are

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deeply striated parallel to the same face in virtue of polysynthetic twinning. Twinning according to $o(111)$ is very common, the forms being simple spinel-like types and complicated fourlings.

The cubic faces show by their striation the intergrown octahedra, and are truncated by brilliant octahedral faces. Cleavage, none; fracture, distinctly conchoidal; lustre, resinous; colour, black; opaque, except in very thin splinters, which are translucent with a dark brown colour, and isotropic; colour of powdered mineral, dark brownish-black, non-magnetic except when containing included grains of magnetite.

Density (weight of 1 cc.)=4·706 at 18°, as determined on 0·5287 gr. hardness, 5·5; brittle.

Chemical Characters.

Heated in closed tube, unaltered; before the blowpipe fuses with difficulty on the edges; insoluble in acids; decomposed by fusion with acid sulphate of potassium.

Method of Analysis.

The finely powdered mineral was fused with acid sulphate of potassium, and the melt dissolved in cold water. Owing to the peculiar behaviour of titanic acid when mixed with zirconia, the former was not precipitated by boiling the dilute solution. The titanic acid, zirconia, and iron were therefore precipitated together by ammonia, the precipitate re-dissolved, and re-precipitated. In the filtrate the calcium and magnesium were determined by the usual methods. The zirconia and titanic acid were separated from the iron by precipitation with sodium thiosulphate. The separation of the zirconia and titanic acid was attempted by a combination of the hydrogen peroxide method of G. H. Bailey (*Jour. Chem. Soc. 1886, Trans.* XLIX. pp. 149, 481) and the acetic acid process of G. Streit and B. Franz (*Select Methods of Chemical Analysis*, Crookes, 2nd ed. p. 98). The greater part of the zirconia was first precipitated by hydrogen peroxide, and the titanic acid precipitated by long continued boiling of the filtrate strongly acidified with acetic acid. Owing to the imperfect method of separation and to the small amount of material used in the analysis, the individual numbers for the zirconia and titanic acid can only be considered as approximate.

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Result of Analysis.

ZrO_2 }	... ...	79·79	48·90
TiO_2 }			30·89
FeO ...	... ...	6·64	
CaO ...	... ...	11·61	
MgO ...	... ...	0·49	
Loss on ignition ...		1·02	
		99·55	

Weight of material used in analysis, 0·2256 gr.

We have dedicated this new zirconia-mineral to Professor Ferdinand Zirkel, of Leipzig (under whom one of us had the privilege to study), in commemoration of his great services in the microscopic investigation of minerals and rocks.

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OBITUARY.

James Dwight Dana.

PROFESSOR James Dana, one of the original corresponding members of this Society, died on the 14th April, 1895, in the 83rd year of his age.

The great loss which his death has inflicted upon science in general has been so widely acknowledged, his eminence as a geologist, a zoologist, and a mineralogist has been so universally commemorated, and the history of his life has already been so well recorded in scientific journals, that it will be sufficient in this brief notice merely to attempt some estimate of the work which this great man effected in the sphere of mineralogical science.

For a full account of his life and labours the reader may be referred to the excellent obituary notice published in the *American Journal of Science*, of which he was an editor for no less than 50 years.

James Dana was attracted to the study of minerals early in life, and in 1833 was working under Professor Silliman at Yale College.

In 1836 he was Silliman's assistant in chemistry, and in 1837 he published the first edition of his *System of Mineralogy*, which afterwards became so well known. At that date the book failed to find a publisher, and was printed at the expense of the author. The system of classification at first adopted was to a certain extent modelled on the Natural History System of Mohs, which classified minerals by their external characters alone. As is well known, the adherents of that system attached absolutely no importance to the chemical characters for purposes of classification, and but little for purposes of identification. But already in Dana's second edition, which was published in 1844, a footnote in the introduction (p. 18) shows that the young author was dissatisfied with the methods of that school. He there says of the chemical characters: "They require for their determination a destruction of the individual, and have therefore been rejected by many distinguished mineralogists who would confine themselves to natural history, or external, characters. After much examination, with prejudices at the time in favour of the above views, I am fully convinced that these alone are insufficient for the determination of many mineral species, often so Protean in so many of their characters."

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This was the first protest on the part of the author against the prevailing views; but in the third edition (1850) the revolution was complete; in the preface to that edition occur the following memorable words, which are so characteristic of Dana's mental attitude towards scientific problems that we quote them in full. "To change is always seeming fickleness. But not to change with the advance of Science is worse; it is persistence in error; and, therefore, notwithstanding the former adoption of what has been called the Natural History System, and the pledge to its support given by the author in supplying it with a Latin nomenclature, the whole system, its classes, orders, genera, and Latin names, have been rejected; and even the trace of it which the synonymy might perhaps rightly bear has been discarded."

It must be remembered that this was written two years before the publication of Rose's Krystallo-chemisches System, which also adopted the chemical composition and the crystalline form as the basis of classification.

Here was in fact an instance of Dana's chief strength; unlike those lesser workers who lose themselves amongst details, or blindly follow other leaders, he was quick to master the details, however great their complexity, to take a wide survey of the subject, and relying on his own judgment to select promptly what was right and essential.

His System rapidly became recognised as the standard Treatise on Mineralogy, and through successive editions has retained its pre-eminence. It is to be regretted that the introductory chapters on Crystallography, Crystallogeny, Chemical and Determinative Mineralogy, &c., which formed so important a part of the earlier editions, were subsequently omitted when the book assumed larger dimensions, for they were filled with useful information and speculations of great interest. Some of these were treated in separate memoirs published at various dates between 1835 and 1874, chiefly in the *American Journal of Science*.

Comparatively few discoveries or original investigations in mineralogical science are associated with the name of James Dana; his mineralogical work was mainly systematic, but it came at a time when, if ever, system was needed, and has done much to raise mineralogy to a position of dignity among the sciences.

It is highly improbable that any individual in the future will achieve such pre-eminence in the three sciences of geology, zoology and mineralogy; it is doubtful whether any individual since the time of Haüy has rendered more substantial and enduring services to the study of minerals.

H. A. Miers.

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NOTES AND COMMENTS.

WE note with regret the death of Francesco Sansoni, Professor of Mineralogy in the University of Pavia. He died on the 28th of March, 1895, at the age of 42; his name will chiefly be associated with the *Giornale di Mineralogia*, of which he was the founder and editor; among his published memoirs the most noteworthy are those upon the crystallography of calcite; during a period of three years Dr. Sansoni, before his appointment at Pavia, was occupied in examining calcite in various European collections, and some results of his studies have been published at intervals during the last few years.

We have received notice of the death of Professor Hermann Knoblauch, the distinguished President of the Kaiserliche Leopoldinisch-Carolinische Akademie, who died on the 30th of June in the 76th year of his age. Also of the death, on the 26th of June, at the age of 27, of Gustav Nordenskiöld, son of the famous Mineralogist and Arctic Explorer, Baron A. E. Nordenskiöld, and himself a Mineralogist of some reputation.

Dr. Richard Brauns, formerly at the technische Hochschule in Karlsruhe, has been appointed Professor of Mineralogy and Geology in the University of Giessen, in succession to Professor A. Streng, who has been compelled to resign on account of ill-health.

Dr. N. V. Ussing becomes Professor of Mineralogy at Copenhagen, in succession to the late Dr. Johnstrup.

Dr. Koken has been appointed to the Chair of Mineralogy and Geology at Tübingen, where he succeeds Professor Quenstedt; Dr. K. Oebbeke, of Erlangen, has been appointed Professor of Mineralogy at the technische Hochschule, of Munich, where he succeeds Professor Haushofer; and Dr. K. Futterer, of Berlin, enters upon similar duties at the technische Hochschule of Karlsruhe.

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Copies have reached us of recent numbers of the two youngest English magazines which deal with general science, namely *Science Progress* and *Natural Science*. Almost every number of the former journal contains articles of mineralogical and geological interest in the form of critical summaries of recent discovery.

The July number (No. 41) of *Natural Science* consists mainly of an interesting series of authoritative articles upon the scientific results of the *Challenger* Expedition, among which we may specially call attention to an article on Coral Reefs by Prof. J. W. Judd, C.B., one on Chemico-biological changes in the Ocean by R. Irvine, and one on Marine Deposits by J. Chumley.

We have received the first part of a new volume on Precious Stones, "Edelsteinkunde," by Prof. Max Bauer, of Marburg, which promises to be an important treatise, embellished with beautiful coloured plates: more detailed review is reserved for our next number.

Dr. Valentine Ball, C.B., F.R.S., Director of the Science and Art Museum in Dublin, died on the 15th of June, 1895, in the 52nd year of his age. He was Professor of Geology and Mineralogy in the University of Dublin from 1881 to 1883, and published numerous papers on geological and mineralogical subjects. His valuable treatise on the Economic Geology of India, in particular, is well known.

The veteran physicist F. E. Neumann died on the 23rd of May, 1895. So long a time has elapsed since the publication of his earliest papers in 1823, and his name has been so prominently associated with other branches of study, that his mineralogical work belongs to a bygone generation; it is difficult to realise that a man who was making most important contributions to physical crystallography seventy years ago could still be living in the present year.

Neumann was born in 1798, and was appointed to the Professorship of Mineralogy in Königsberg in 1828, having been attracted to that subject by Weiss.

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REVIEWS.

A Treatise on the Morphology of Crystals: by N. Story-Maskelyne, M.A., F.R.S. (Clarendon Press, Oxford, 1895.)

The publication of Prof. Maskelyne's long anticipated treatise on morphological crystallography marks an era in the history of the science in this country. Hitherto the English student who desired to pursue the subject beyond the mere attainment of a superficial acquaintance has been obliged to have recourse to the admirable treatises in the German and French languages. This, however, is no longer necessary as far as the morphological side of crystallography is concerned, and we now have this fascinating subject most fully treated in our own language, and in an entirely original and delightful manner. The book is constructed upon the plan of the author's Oxford lectures, and those who have not been privileged to enjoy the lectures themselves may now follow the lecturer at their leisure through the wonderful maze of crystalline forms, and develop something of his own enthusiasm as he traces the interesting connection between them.

The basis of the book is eminently mathematical, yet the reasoning is usually sufficiently simple to be incapable of repelling those whose mathematical training has not been of an advanced character, while on occasion sufficiently deep to be a source of satisfaction even to the more mathematically inclined. An admirably lucid explanation of the stereographic representation of crystals is given, accompanied by a sufficient selection of theorems in pure spherical trigonometry to enable a beginner to readily work out any problem in practical crystallography which may present itself. Equally clear and precise are the sections which treat of the fundamental laws of crystal morphology, the rationality of indices, the zone law, and the law of anharmonic ratios, while the Millerian method of notation appears simplicity itself as explained by Prof. Maskelyne. There is, however, one point to which the attention of students about to use the book might with advantage be drawn. It is to some extent unfortunate that the nomenclature of the two lateral axes of a crystal employed by Prof. Maskelyne is the reverse of that adopted by Groth in his invaluable *Zeitschrift für Krystallographie*, and by the whole of the

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modern German school. Whilst the axis passing from front to back of the crystal is termed the A-axis, corresponding to the Millerian plane (100), in the German scheme, and the axis passing from right to left is lettered B, corresponding to the plane (010), Prof. Maskelyne terms the former the B axis and the latter is designated A. So long as students are fully aware which scheme they are employing, it is of course a matter of no importance, although one cannot but regret that the two systems are not brought into unison, in order on the one hand to avoid confusion in comparing data from German and English sources, and on the other hand in order to save the considerable labour involved in a revision of the facial symbols in translating from one language to the other. For this reason the writer of this review has adopted the German scheme of lettering the lateral axes in all original communications.

Upon the chapters concerning the symmetry of crystals it would be almost impossible to bestow too much praise. The large importance attached to symmetry is indeed a feature of the book, and in carrying it to its logical conclusion Prof. Maskelyne is led to make a most interesting statement, almost prophetic, considering that this portion of the work has been in the press for some time, of the direction in which crystallographical research is now tending. Prof. Maskelyne speaks (p. 171) of crystal symmetry as a geometrical abstraction, which "needs for its development and due explanation a complete science of position applied to the molecular mass-centres, competent to embrace not merely the relative distribution *inter se*—the *intermolecular* distribution—of the chemical molecules constituting the crystallised substance, but also the *intromolecular* arrangement of the atoms, or molecules of secondary order, whereof the molecules of the substance are themselves composed. Then the true significance of the ideal planes and axes of symmetry will be understood, and they will assuredly retain a place in the explanation of crystalline symmetry, since they rise into recognition directly from the fundamental principle of rationality of indices, and are controlled by its consequences." It is somewhat to be regretted that Prof. Maskelyne has not found it convenient to follow up this prescient statement with a *resumé* of the attempts which are being made to-day to ascertain the nature of the molecular mass-centres, and to unravel the mode of distribution within them of the chemical molecules and the atoms of which the latter are composed. A criticism of these researches from his master mind could not fail to be of the greatest use to those who are engaged in attempting to penetrate into this obscure but fundamental region of morphological crystallography. Moreover, we miss in the present volume all allusion to

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the remarkable mathematical investigations of Sohncke, Fedorow, and Barlow as to the possible modes of distribution in space of the molecular mass-centres. However, Prof. Maskelyne promises us a second volume, and doubtless will introduce into it, along with the consideration of the physical properties of crystals, these most interesting questions relating to their ultimate structure. For what can the morphology of crystals depend upon other than the nature, that is to say the internal structure—and all that this implies as regards the distribution of the matter composing it, the state of motion or equilibrium of the atoms, and the form, store and distribution of energy—of the organised aggregate of chemical molecules which is now currently regarded as the crystallographical unit or crystal-element? It must be that the forces which bind together these crystal units in such perfection of symmetry entirely depend upon the nature of the crystal element as thus defined, and that no comprehensive theory of the ultimate structure of crystals can be arrived at until more knowledge is gained as to the morphology of the crystal element itself.

In the latter portion of the book Prof. Maskelyne gives an admirably practical account of the use of the goniometer, including a full description of Websky's mode of adjusting the instrument. This is followed by a series of carefully chosen examples of crystallographical calculations, and an exceedingly useful account of the current modes of drawing crystals from the ascertained crystallographic elements. It is earnestly to be hoped that Prof. Maskelyne will see his way to complete the further volume in the near future, when he will have made the most important addition to the crystallographical literature of this country since the publication of the fundamental work of Miller. A. E. Tutton.

An introduction to Chemical Crystallography: by Andreas Fock, Ph.D., translated and edited by W. J. Pope. (Clarendon Press, Oxford, 1895.)

Mr. Pope has rendered a great service to Chemical Crystallography by his translation of the work of Dr. Fock. It is still, unfortunately, a matter of regret that, owing to our totally inadequate methods of secondary education, comparatively few students in this country are enabled to read continental authors in the original, and many who are consequently unable to peruse with advantage the compact little book of Dr. Fock, and the still more recent and comprehensive treatise of Prof. Arzruni of Aachen, will feel indebted to the translator of the former. The relationship between chemical composition and crystalline form is as yet so little understood, that no book on the subject can hope to do more than present a clear idea of the stage to which investigation has reached, and the

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direction in which it is tending. The opportunities which are afforded to the chemical investigator of studying the crystallographical properties of definitely related substances which he prepares in the course of his synthetical operations, are so numerous that it is greatly to be desired that every student of chemistry who intends to pursue the subject should take up as part of his training a course of practical crystallography. For, as Prof. Maskelyne very truly remarks in a preface with which he introduces Mr. Pope's translation, the crystallographical and physical constants of the new substance are as much a part of its nature as its composition and chemical relationships.

The earlier chapters of the work are devoted to the history of the science, to the modes of formation of crystals, the influence of water of crystallisation upon the geometrical form, and the current views as to the state of the included water. Double salts are next considered in the light of the recent work of Rüdorff, Trevor and Willard Gibbs, and the four conditions of saturation-equilibrium for the pair of simple salts constituting the double salt discussed. Very interesting chapters then follow on the growth of crystals and the nature of crystallites, and a full account is given of the recent explanation of the phenomena by Lehmann on the basis of the variations in the concentration of the environing solution. The most important portion of the book, however, is that which connects crystalline form with chemical composition, and here again very considerable additions to the text have been made by Dr. Fock, and also, with his sanction, by Mr. Pope, in order that the most recent investigations shall be included. The work of Muthmann upon the arsenates and phosphates, and of the writer of this review upon the sulphates and double sulphates containing potassium, rubidium and cæsium, is discussed, and, in short, the translation affords a fairly complete account of the subject up to date. Perhaps one small oversight might be mentioned. On page 104 occur the words: "Although no close relationship can be observed between the indices of refraction of the three salts, yet it will be seen that the refractive indices of rubidium sulphate are intermediate between the corresponding indices of potassium and cæsium." As a matter of fact, they do bear a most interesting relationship, which is fully discussed in the memoir referred to, and is clearly seen when they are graphically represented by curves, and still more clearly when the corresponding optical elasticity relationships are calculated from them and similarly expressed by curves. The change of atomic weight of the metal is indeed most accurately reflected in the optical behaviour of the three salts, and is directly responsible for the beautiful and quite exceptional optical characters of rubidium sulphate.

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The nature of physical isomerism, formerly termed dimorphism, affords the subject for another particularly interesting chapter, and although the distinction of Lehmann between physically polymeric and physically metameric substances would appear at present to be of a somewhat superfine character, still it can no longer be doubted that the phenomenon of a single chemical substance crystallising in more than one crystalline form depends essentially upon a different constitution of the crystal-element, the physical molecule, whether the difference is in the number or the arrangement of the chemical molecules of which it is composed. So soon as a satisfactory method is discovered of determining the composition of the physical molecule, we shall be able to to solve this, as well as many other problems of great interest. Indeed, it would seem that such a method is the great desideratum at the present moment, and it will be of distinct service if the translation of Dr. Fock's book calls attention to the fact. The concluding chapters on isogonism and morphotropy afford still further food for thought, and here again it is shown that there is much probability in the supposition of Groth that the crystal-elements of morphotropic substances are of the same magnitude, and that, therefore, the explanation of morphotropy will in all likelihood follow the discovery of a method of determining that magnitude.

The translation of Mr. Pope has a further advantage over the first edition of the original, besides the fact that it is in our own language, inasmuch as many errors, typographical and otherwise, had crept into the German text; these are all corrected, and Mr. Pope has had the additional good fortune to find in Mr. Miers, of the British Museum, an experienced friend to assist him in the revision of the manuscript and proofs.

A. E. TUTTON.

Recherches Minéralogiques of Prof. M. Tolstopiatow. Posthumous edition, pp. xxviii., 186. Moscow, 1893.

M. Tolstopiatow, who was for 30 years Professor of Mineralogy in the University of Moscow, seems to have published comparatively little of his work, but left behind him, at his death in 1890, numerous papers and notes. These, which are somewhat fragmentary in places, have been collected and edited by M. Kriloff to form, together with a biographical notice, the present volume. His favourite subject related to crystallogenesis and the structure of crystals, but a large part of the book is taken up by his observations on the *absorption brushes of epidote*. The latter subject commences with a historical review, in which it is pointed out

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that some previous observers have confused the true absorption brushes with the idiocyclophanic pictures seen in epidote, and with the interference phenomena due to polarised light from the sky and the polarising action of the crystalline lens of the eye (to which Haidinger's brushes are due). Mention is made of Bertrand's statement that absorption brushes are to be seen in dichroic uniaxial crystals, as well as in biaxial crystals; this, however, is doubted. Instead of cutting plates perpendicular to the two optic axes, the author has preferred to view the unprepared crystals through the faces c (001) and r ($\bar{1}01$), these being nearly perpendicular to the two optic axes. The same crystal can then be viewed along both axes, with the result that, owing to the twinning of epidote, differences in the two sets of brushes can be seen. The crystals are viewed in ordinary and in polarised light (from the sky or with a nicol), and several beautifully coloured plates are given of the absorption and interference phenomena seen. The "primary" or absorption brushes, which depend on the unequal absorption of the two rays, are disposed in the direction of the orthodiagonal of the crystal (epidote), and do not change their position when a nicol placed in front is rotated, there being only a transposition of the colours. The brushes are often more distinct when viewed through one face than when viewed through the parallel face. The "secondary" or interference brushes (idiocyclophanic), due to an enclosed twin lamina, are of comparatively rare occurrence. It is here supposed that the light is polarised in the crystal, not by the greater absorption of one ray, but by the twin laminæ, with layers of air or of decomposed epidote between, acting as a pile of plates. Notes are also added on the polarisation of the atmosphere, and on the brushes seen in lepidolite and muscovite in natural light.

The second part of the volume, on *the structure of crystals*, is very hypothetical, and commences with the assertion that crystals are not homogeneous, but consist of a nucleus and an envelope, the former being regularly constituted, and the latter irregularly—in fact, a sort of accidental growth. This nucleus, which is called the *cryptopyramid*, and denoted by kP, is said to manifest itself, and to be distinguished from the envelope, by differences of colour, dichroism, arrangement of enclosures, cleavage, fracture, and character of the optic pictures (*e.g.* when the nucleus is uniaxial, the envelope is biaxial; variation of the value of 2 E, as in topaz), these being taken to indicate differences in structure of the two parts. This important crystallographic unit, said to be the primitive form (from which the parametral ratios are calculated in terms of the number of molecules along the axes), can sometimes actually be seen in

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the interior of a crystal as an acute elongated pyramid, singly (in this case taken to indicate hemimorphism, *e.g.* calcite) or doubly terminated. Much importance is also attached to complicated systems of striæ seen in the interior of crystals.

There are also notes on hemimorphism, twins, pleochroism, asterism, &c. From the character of the "cryptopyramid" topaz is regarded as hemimorphic. From certain fissures and marks on the faces it is inferred that topaz is twinned, showing both polysynthetic and crossed twins. L. J. S.

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Abstracts.

New Minerals from Greenland (G. Flink, *Zeits. für Kryst.* XXIII. 344, 1894).—The exact locality is not certain; but as the minerals occur in cavities (which are not known in the syenitic pegmatite veins of Kangerdluarsuk) and are associated with certain minerals known to occur at Narsasik near Igaliko, they probably come from the latter locality.

Neptunite.—This new mineral occurs as brilliant black crystals of a vitreous lustre on ægirine and orthoclase; the habit is octahedral, owing to the equal development of the forms *c* (001), *m* (110), *u* ($\bar{5}12$), *d* ($\bar{3}01$), which are present on all crystals.

$$a : b : c = 1{\cdot}31639 : 1 : 0{\cdot}8075;\ \beta = 64°22'$$

Cleavage *m* perfect; sp. gr. 3·234. In thin sections is blood-red by transmitted light and pleochroic; optically positive. The formula is given as:—

$$TiO_3\,(\tfrac{2}{3}\,Fe + \tfrac{1}{3}\,Mn).Si_4O_9\,(\tfrac{3}{4}\,Na_2 + \tfrac{1}{4}\,K_2),$$

which may also be written as a titano-silicate. Owing to the close similarity of the crystal angles to those of sphene, neptunite is placed in the titanite group.

Epididymite.—This new mineral has the same composition ($BeNaHSi_3O_8$) and density (2·55) as eudidymite; the two, however, differ in crystalline form and the optical constants, the former being ortho-rhombic and the latter mono-symmetric. Epididymite occurs as colourless crystals deeply striated and elongated parallel to the macrodiagonal.

$$a : b : c = 1{\cdot}7367 : 1 : 0{\cdot}9274.$$

Twins have the individuals crossing at nearly 60°, as in eudidymite; but twinning is mostly only seen in polarised light as crypto-twinning. Very perfect cleavage parallel to the base and macropinacoid. Optically negative. A more or less close relation is shown to exist between the crystal angles of epididymite and eudydimite.

Catapleiite, which was only before known from Norway, is described from this locality as large hexagonal tables with the hexagonal pyramid

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(522). Through the basal plane a biaxial optic picture, with small axial angle, is seen. Analysis shows it to be soda-catapleiite.

The *ægirine* crystals are described, and three types distinguished, depending on the habits of the crystals and the optical relations. Descriptions are also given of the other associated minerals. L. J. S.

Gold.—The following series of papers is communicated by A. Liversidge to the *Jour. Roy. Soc. N. S. Wales*, 1893, pp. 1-61 :—

Origin of Moss Gold.—After roasting auriferous mispickel, at a temperature below the melting point of gold, the specimens are seen to have ochre-coloured exudations on their surfaces; these consist of gold in cauliflower-like aggregations, and under the microscope are seen to be made up of spicules and spirals of gold. The same result is obtained on roasting a mixture of gold and mispickel.

When arsenic vapour is passed over gold foil, at a dull red heat, yellow brittle globules of a very fusible arsenide of gold (with 2—10 % As) are formed. On cooling, the globules spurt and give off arsenic, giving rise to the lustreless excrescences of moss gold, while cavities contain spirals and spicules of gold. A similar phenomenon is seen in fused bituminous coal and the forms assumed by the resulting coke. The gold in auriferous mispickel appears to be in the free condition, and to be converted into the fusible gold arsenide on roasting.

The condition of gold in quartz and calcite veins.—In order to ascertain whether the gold scattered through quartz veins and other gangues is crystalline or not, the matrix was dissolved away by hydrofluoric or other acid. The gold thus set free from quartz usually presents the appearance of irregular films, plates, threads and masses which are more or less connected together, or as dull brown powder, and only rarely showing any signs of crystallisation, the two minerals having apparently solidified together, neither being able to crystallise freely.

The really good crystals of gold all appear to have formed in what are now cavities, usually left by the removal of iron pyrites, or else in soft matrices like iron oxides, clay, calcite and serpentine.

Origin of Gold Nuggets.—Besides the old and generally accepted view that alluvial gold has been set free from mineral veins and rocks by denudation, various theories have been put forward to explain its origin, the principal one being that of Dr. A. R. C. Selwyn, who suggested that nuggets grow in alluvial deposits by the deposition of gold, from solution on their surface. The author gives an exhaustive and critical review of

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the literature bearing on the subject, and adds numerous careful experiments of his own.

Various metallic sulphides (pyrites, galena, &c.), on being placed in a solution of double chloride of gold and sodium, soon become coated with reduced gold, either as a bright coherent deposit, or as a dull ochre-coloured one. On placing in the solution a gold nucleus (a nugget or plate) with inorganic matter (pyrites, mispickel, etc., graphite, sand, clay, granite, etc.) with the object of forming a galvanic couple, dull gold with a mamillated structure was deposited on the nucleus as well as on the inorganic matter. With organic matter gold was reduced but none deposited on the nucleus, as has been stated to be the case by previous authors. Having shown that gold can be deposited from solution on a nucleus of gold, the author discusses the evidence of the existence of gold in natural waters. Only in sea water is there direct chemical evidence of the presence of gold, nevertheless it must have been present in the water from which recent auriferous pyrites, &c. has been deposited; and it is now being deposited by the hot springs of Nevada and California. Gold is soluble in solutions of alkaline sulphides, carbonates and silicates.

The author has thus shown that it is theoretically possible for nuggets to have grown *in situ*, but he is of the opinion that large nuggets at least have not been formed in this way, but have been derived from reefs, and that any small addition of gold they may have derived from meteoric waters is quite immaterial. Against the arguments used in favour of the theory of growth *in situ*, it is pointed out that the difference in composition of nugget and vein gold is usually small, and sometimes vein gold is even richer than alluvial. The roughnesses of vein gold would be flattened down by abrasion, the water-borne sand and pebbles acting in every crevice; the surface of the malleable gold would thus assume a mamillated appearance. Masses of gold have been found in veins comparable in size with the largest nuggets. In favour of the old theory it is pointed out that large nuggets have some reef quartz attached to them; besides, the pebbles of gold-bearing alluvium are admitted to have come from gold reefs; that being so, why should we seek for another origin for the associated water-worn pebbles of gold? And why is alluvial gold not found as plates and strings if it has been deposited *in situ*?

Crystallisation of Gold in Hexagonal Forms.—The gold deposited on various metallic sulphides (copper pyrites, blende, &c.) placed with a gold nucleus in a solution of gold (*v. supra*) took the form of bright minute prisms, six-rayed stars, and hexagonal plates. "In no case were there any traces of gold in forms belonging to the cubical system,"

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although these are so readily obtained by reducing gold with ether, oxalic acid, &c. Such hexagonal forms have been previously recorded, and are regarded by E. S. Dana to be due to elongation or compression along a trigonal axis.

Gold Moiré-métallique.—In many cases the gold plates, used in the above experiments on the reduction of gold from solution, presented a moiré-métallique appearance, as seen on tin plates and galvanised iron. The whole surface of the plate being dotted over with more or less regular crystals, very small, and much more regular and rectangular in outline than those on tin plate. This effect may also be brought about by boiling pure gold foil or plate in hydrochloric acid. L. J. S.

Leadhillite from Missouri and its Chemical Composition (L. V. Pirsson and H. L. Wells, *Am. J. Sc.* XLVIII. 1894, p. 219). — This rare mineral occurs with cerussite at a new locality, Granby, Missouri, in rather slender, apparently hexagonal prisms, attaining a length of 5 cm., or more commonly in thick hexagonal tables 1 cm. across. The colour varies from colourless in the smaller transparent crystals to clear sea-green in the larger translucent individuals. The usual forms present are the basal plane, unit prism and orthopinacoid, with sometimes hemidomes and pyramids (e ($\bar{2}01$), u (201), q ($\bar{4}14$), μ ($\bar{4}18$)). The angle β was measured as 89°38′. Twinning on the unit prism is common, often giving rise to twin lamellæ ; the scattered images of the goniometer signal from the perfect basal cleavage of such individuals show the mineral to be oblique (the measured angles closely approach those required by hexagonal symmetry). Twins with the basal plane as the plane of combination are sometimes indicated by the optic pictures being crossed at 60°, as in mica. The mineral becomes uniaxial at a temperature below 100°C. ; in the course of a day or so the uniaxial character disappears and the normal one is resumed. Etching figures on the basal cleavage agree with the oblique symmetry, and are very like those of mica.

Previous analyses of the mineral have varied somewhat widely, the earlier ones disregarding the water, so that various formulæ have been given. The present analysis agrees very closely with the simple formula assumed by Groth, $[SO_4]\ [CO_3]_2\ Pb_2\ [Pb{\cdot}OH]_2 = 4PbO{\cdot}2CO_2{\cdot}SO_3{\cdot}H_2O$. A large pure crystal was used, the water and carbon dioxide being driven off by heat and weighed directly, and the ignited residue fused with sodium and potassium carbonates. Sp. gr. 6·54. L. J. S.

Sulfoborite (H. Bücking, *Sitz. k. preuss. Akad. Wiss.* XLIV. 967,

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1893). This new mineral has been found at Westeregeln with celestine, the latter not having before been noticed from the Egeln-Stassfurt salt beds. The colourless or reddish isolated crystals belong to the orthorhombic system, and five habits, depending on the relative sizes of the unit prism and pyramid, and the brachypinacoid and basal plane (which are the only prominent forms) are figured :

$$a : b : c = 0{\cdot}6196 : 1 : 0{\cdot}8100.$$

The cleavage (101) is good, that parallel to the basal plane is less perfect. Sp. gr. 2·38 to 2·45. The chemical formula is given as $3MgSO_4 \cdot 2Mg_2B_4O_9 \cdot 12H_2O$. This is the representative of a new mineral group analogous to the mixed borate and phosphate of magnesium, viz. lüneburgite. L. J. S.

Crystallographic determinations of new Chilian Minerals (A. Osann, *Zeits. für Kryst.* XXIII. 584, 1894).—These minerals from the salt beds of Chili have recently been described by A. Dietze (*Zeits. Kryst.* XIX. 445, 1891), and are interesting as representing new groups of minerals.

Darapskite.—Composition: $NaNO_3 + Na_2SO_4 + H_2O$. The colourless mono-symmetric crystals are tabular parallel to the orthopinacoid, and the principal forms are in the orthodome and prism zones—

$$a : b : c = 1{\cdot}5258 : 1 : 0{\cdot}7514; \ \beta = 77°5'.$$

Twinning on the orthopinacoid is frequent, sometimes as polysynthetic twins; the same face is also parallel to the cleavage. Sp. gr. 2·203. The locality is Pampa del Toro, where also good crystals of Blödite occur.

Lautarite.—Composition: $Ca(IO_3)_2$. The transparent wine-yellow to almost colourless crystals are mono-symmetric with prismatic habit, and terminated by a large basal plane and small unit clinodome faces, the latter being parallel to the cleavage. Sp. gr. 4·59.

$$a : b : c = 0{\cdot}6331 : 1 : 0{\cdot}6462; \ \beta = 73°38'.$$

Dietzeite.—Composition: $7\,Ca(IO_3)_2 \cdot 8\,CaCrO_4$. This mineral occurs in fibrous aggregates, and is of a dark gold-yellow colour; distinct crystals, which are mono-symmetric and tabular parallel to the orthopinacoid, are rare.

$$a : b : c : 1{\cdot}3826 : 1 : 0{\cdot}9515; \ \beta = 78°28'.$$

An imperfect cleavage exists parallel to the orthopinacoid. Sp. gr. 3·698. The name dietzeite is proposed after the discoverer. L. J. S.

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Chemical behaviour of Pyrites and Marcasite (A. P. Brown, *Proc. Am. Phil. Soc.* XXXIII. 225, 1894). An attempt is made, by means of numerous experiments, to arrive at the constitution of these bodies, it being remarked that little work has been done in this direction amongst minerals. In review are given the various methods which have been successful in the artificial production of pyrites, and it is noticed that marcasite has not been formed artificially. Their possible modes of formation in nature are also suggested, and their weathering discussed, it being noticed that pyrites gives rise to limonite (as is seen in the numerous pseudomorphs) and free sulphur, while the less stable marcasite gives rise mainly to ferrous sulphate with little limonite. In one series of experiments the minerals were treated with solutions of potassium permanganate of various strengths, and at various temperatures, with the object of oxidising the sulphur, but the curves plotting the results show no marked difference between pyrites and marcasite. Dry hydrochloric acid gas at an elevated temperature acted more readily on pyrites than on marcasite. The amount of ferrous and ferric iron in the minerals was determined by heating with copper sulphate solution in sealed tubes, and titrating with permanganate, and it was found that, while all the iron of marcasite existed in the ferrous state, only 8·91 per cent. of the iron in pyrites was in this state. Marcasite has then the formula $Fe''S_2$, and pyrites $4\,Fe''S_2{\cdot}Fe''S_2$. The formula indicates that marcasite is an unsaturated compound, the two sulphur atoms being linked together, and thus may be explained its more unstable nature. L. J. S.

Lindesite (L. J. Igelström, *Zeits. für Kryst.* XXIII. 590, 1894). This mineral occurs in gneiss with other manganese compounds in the Glakärn mine, Linde, Örebro. The brownish-red crystals appear to be mono-symmetric or asymmetric, and have good cleavages in three directions. The important constituents are as follows, those of urbanite being added for comparison :—

	SiO_2	Fe_2O_3	MnO	CaO	MgO	Na_2O
Lindesite	48·37	21·92	10·97	5·76	3·49	6·12
Urbanite	51·61	27·24	1·73	4·90	2·95	10·59

The formula suggested is $3\,RO{\cdot}SiO_2{\cdot}R_2O_3SiO_2$. The mineral approaches acmite and rhodonite. Urbanite was the name recently given by Sjögren to the so-called "iron-schefferite" of Långban. Should lindesite and urbanite prove to be identical, the author claims priority for the former name.

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Pyrrho-arsenite. This mineral occurs with rhodonite in the Sjö mines, Grythyttan. The composition, which does not correspond very closely to that of an orthoarsenate, differs from that of berzeliite in containing more manganese (28·38 per cent.), and rather less calcium and magnesium, so that the mineral may be considered as a manganese-berzeliite. L. J. S.

Lossenite, a new Laurium mineral (L. Milch, *Zeits. f. Kryst.* XXIV. 100, 1894). Occurs as small, reddish-brown, lustrous, pyramidal crystals, strongly resembling scorodite in appearance, and often coated with brown ferruginous and olive-green decomposition products. Besides the unit orthorhombic pyramid, pinacoid (*a* (100)) and prism faces are sometimes present. Only rough measurements can be obtained between the pyramid faces, giving $a:b:c = 0{\cdot}843:1:0{\cdot}945$. These parameters are very close to those of scorodite, and the optical characters of the two minerals are identical. After deducting 1·13 per cent. of SiO_2 and 1·46 per cent. of $CaCO_3$, the formula is given as $2\,PbSO_4+6\,(FeOH)_3As_2O_8+27H_2O$. The mineral, to which the name *Lossenite* (after A. C. Lossen) is given, thus differs from scorodite by the presence of $PbSO_4$ and water of constitution, and in the greater proportion of water of crystallisation.

L. J. S.

Beryl from Pisek, Bohemia (C. Vrba, *Zeits. für Kryst.*, XXIV., 104-123, 1894). In the felspar quarries near this place occur two varieties of beryl—one, opaque common beryl, and the other transparent and yellow, or bluish-green noble beryl. The first is more or less decomposed, with bertrandite in cracks and cavities: one crystal proved to be a twin, which has not been before observed in beryl. The angle $2\bar{1}\bar{1}:2\bar{1}\bar{1}$ between the two individuals of the twin was measured as 84° 55′, which agrees with (8, 47, $\bar{3}1$) being the twin plane, or the plane ($\bar{7}$, 8, 23) which is nearly at right angles to the last may be taken. The transparent crystals are deeply etched and corroded, but quite fresh. Measurements of the etch-faces are given, among which are several new forms.

Bertrandite from Pisek. In a new felspar quarry small crystals of bertrandite occur with crystals of albite and apatite in cavities having the shape of hexagonal prisms. These cavities are negative crystals after beryl, the decomposition of which has given rise to the bertrandite. The crystals are well developed, and tabular parallel to *b* (010). Simple crystals are rare, two to four individuals being twinned together with *e* (041) as twin plane. The crystals from several other new localities in

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the felspar quarries near Pisek are described: at Ober-Neusattel large crystals occur, and here anatase, which is new to Bohemia, was found.

Phenakite from Ober-Neusattel. This occurs with the bertrandite, and in the same manner, having also been produced by the decomposition of beryl. Several crystals are figured and described, some of which are interpenetrating twins with parallel axes: $c=0{\cdot}660905$. Analyses of beryl and phenakite, agreeing closely with theory, are given.

L. J. S.

Crystallography of Cassiterite (W. Kohlmann, *Zeits. für Kryst.* XXIV. 350-365, 1895). Descriptions and measurements of crystals from numerous localities are given under Becke's three types, which are to a certain extent characteristic of special localities:—(1) Crystals with equal extension of the vertical and lateral axes, no basal plane, and frequently twinned (Erzgebirge); (2) "Needle-tin," with the acute pyramid (551) largely developed (Cornwall); (3) Basal plane prominent (Pitkäranta). A fourth type is added in which the pyramid *s* (111) predominates. This was observed by the author from Tasmania and Zinnwald. Of twin crystals, three habits of twinning are distinguished. A complete list of forms is given, with the evidence as to their first discoverers. A few new forms are given. The variations in colour of the mineral are described, and the colour of a yellow crystal from Perak, with 0·11 per cent. of WO_3, is doubtfully attributed to tungsten. The modes of occurrence and associated minerals from different localities are described.

L. J. S.

Breithauptite (K. Busz, *Neues. Jahrb. Min.* I. 119-124, 1895). —As crystals of this mineral have not been measured since Breithaupt's measurements in 1840, the author has examined a few very bright crystals, found embedded in calcite from Andreasberg. Breithaupt suggested the mineral to be isomorphous with pyrrhotite, and therefore gave the two pyramids the indices $i(411)$ and $w(8\bar{1}\bar{1})$, (with the dirhombohedra (011) and $(\bar{3}55)$); the prism $a(2\bar{1}\bar{1})$, and the basal plane $c(111)$ were also present: $a:c=1:0{\cdot}8586$. Groth supposed the mineral to be rhombohedral and isomorphous with millerite, in which case the pyramids and prism will be of the second order, with the symbols $a(01\bar{1})$, $c(111)$, $i(741)$, $w(13, 4, \bar{5})$; and $a:c=1:0{\cdot}9914$. The crystals measured by the author show no suggestion of rhombohedral symmetry, and they are not tabular in habit as those of Breithaupt, but pyramidal (w) truncated by the basal plane. The planes of the form w are smooth

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and very bright near the basal plane, but towards the prism they are striated horizontally. The observed forms were $c(111)$, $a(2\bar{1}\bar{1})$, $w(8\bar{1}\bar{1})$, $s(5\bar{2}\bar{2})$. The mean of 11 measured angles for cw was 56° 10′ 40″ (limits 55° 58′ – 56° 30′), this gives $a : c = 1 : 0{\cdot}8618$. For ww' the mean of 9 measurements was 49° 7′ 20″ (limits 48° 41′ – 49° 15′), this gives $a : c = 1 : 0{\cdot}8636$. Taking the mean of these:

$$a : c = 1 : 0{\cdot}8627.$$

Placing the crystals in Groth's position, the symbol for s is $(23, 2, \bar{19})$, and $a : c = 1 : 0{\cdot}9962$.

A twin crystal, consisting of two equally developed individuals with w as the twin plane and face of composition, was observed: the forms present were w and c; $c\bar{c}$ measured 67° 42′, calculated 67° 35′.

A review of the literature of breithauptite and arite is given.

L. J. S.

Caledonite from Leadhills. (K. Busz, *Neues Jahrb. Min.* I. 111-115, 1895).—Owing to the differences observed in the angles between different faces of the same forms, there has been some doubt whether this mineral is rhombic or oblique; these differences are, however, quite irregular, and the author considers the crystals as rhombic. He gives the forms: $c(001)$, $t(113)$, $s(223)$, $r(111)$, $v(774)$, $w(221)$, $m(110)$, $i(012)$, $k(023)$, $e(011)$, $a(010)$, $x(201)$.

Calculated from $mm = 85° 9'$ and $cx = 71° 53'$:—

$$a : b : c = 0{\cdot}91874 : 1 : 1{\cdot}40407.$$

Kokscharov deduces from the measurements of all authors:—

$$a : b : c = 0{\cdot}91753 : 1 : 1{\cdot}41322.$$

The habit of the crystals is as usual prismatic parallel to the brachydiagonal. The brachydomes and brachypinacoid are strongly striated parallel to their intersections. There is no sign of twinning, and the crystals are optically uniform throughout. The optical characters agree with rhombic symmetry. All the Leadhills crystals have been considered as rhombic, while those from Rezbanya and Beresovsk are considered, by Schrauf and Eremyeev respectively, to be oblique. L. J. S.

Kamarezite, a new mineral from Kamareza, Laurium. (K. Busz, *Neues Jahrb. Min.* I. 115-119, 1895).—A small specimen of a grass-green mineral in the Bonn Museum was suspected to be a new species, on account of it giving off more water in a closed tube than brochantite, which it some-

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what resembled. The mineral shows a crystalline structure, and contains many small cavities filled with needle-shaped crystals. The mean of four partial analyses was :—

CuO	FeO	SO_3	H_2O
51·50	0·69	17·52	30·29

This agrees with $3CuO{\cdot}SO_3{\cdot}3H_2O = SO_4(CuOH)_2 + Cu(OH)_2 + 6H_2O$. The loss of water begins at about 220°, and up to a dull red heat about half the total amount is given off, the colour of the mineral changing to black; at a higher temperature some SO_3, as well as more water, is expelled. Spec. gr. = 3·98: H = 3. Decrepitates when heated. Insoluble in water; soluble in acids and ammonia.

Crystals are too small for goniometric measurement; under the microscope they are seen to be needles, probably orthorhombic, tabular parallel to what is taken as $b(010)$, and elongated and striated in the direction of the c axis. Perpendicular to the plate and parallel to the striations is a perfect cleavage, $a(100)$. The needles are terminated by macrodomes $c(101)$ and $d(201)$, with angles, measured under the microscope, $ac = 60°$, $ad = 31°$; these give $a : c = 1 : 0{\cdot}601$. Perpendicular to a is a bisectrix, with a large optic angle, the plane of the optic axes being parallel to b.

L. J. S.

Pyrrhotite. (K. Busz, *Neues Jahrb. Min.* 1895, I. 124-127).—Small steel-blue, tabular crystals on calcite from Andreasberg showed a low pyramid $t(221)$ with $m(2\bar{1}\bar{1})$ and $o(111)$. The basal plane was always a little curved, and the pyramid horizontally striated, the prism being bright and smooth. Taking $a : c = 1 : 1{\cdot}65022$, as determined by Seligmann on crystals from the Cyclopean Islands, to be the most accurate and reliable :—

	Calculated.	Measured.	Limits.
mt	64° 32′	64° 46′	64° 38′ – 64° 55′
tt	24° 50′	24° 32′	24° 17′ – 24° 40′

Nearly all measurements made hitherto on pyrrhotite have been only approximate, those by G. Rose for zz varying from 126° 49′ to 127° 25′ on different crystals; these give $a : c = 1 : 1{\cdot}74015$ and $1 : 1{\cdot}65376$ respectively, the latter being near Seligmann's determination. The recorded forms are : $o(111)$, $a(2\bar{1}\bar{1})$, $b(10\bar{1})$, $t(211)$, $s(110)$, $z(100)$, $u(5\bar{1}\bar{1})$, $w(7\bar{2}\bar{2})$, $y(16, \bar{5}, \bar{5})$, $v(52\bar{1})$, (741).

A table of calculated angles is given in the paper.

Streng measured the angles 61° and 24° 4′ from pyramids to the prism

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on crystals from Chañarcillo and Kongsberg respectively. These pyramids give simpler indices when referred to the second order:—

	Calculated.	Measured.
$b : 321$	61° 11′	60° – 62°
$321 : 312$	27° 53′	27° 30′ – 29° 20′
$b : 31\bar{1}$	24° 26′	23° 48′ – 24° 23′

D'Achiardi measured on crystals from Bottino (Tuscany) an angle of about 10° from a low pyramid to the basal plane: $c : 343 = 10°\ 47'$ calculated. L. J. S.

Baddeleyite from Brazil (E. Hussak, *Tsch. Min. Mitth.*, XIV. 395-406, 1895. Two Plates).—The present paper gives a more complete account of the mineral than when it was first described by the author under the name brazilite (*Neues Jahrb. Min.* II. 141, 1892). The mineral occurs in the iron mine of Jacupiranga, S. Paulo, as an accessory constituent in decomposed magnetite-pyroxenite (jacupirangite), and also rarely in the limestone contact with this rock. The crystals are tabular parallel to the orthopinacoid, and are mostly 2 – 3 mm. (the largest 5 mm.) across. The colour is usually brownish, but according to the amount of iron present, varies from colourless and transparent to black and opaque. The parameters are now given as:—

$$a : b : c = 0{\cdot}9871 : 1 : 0{\cdot}5114\ ;\ \beta = 98°\ 45\tfrac{1}{2}'\ :$$

these being derived from the measured angles, $am = 44°17\frac{1}{2}'$; $ac = 81°\ 14\frac{1}{2}'$; $cr = 29°\ 4\frac{1}{4}'$. The forms present are: $a(100)$, $b(010)$, $c(001)$, $m(110)$, $k(120)$, $l(230)$, $p(221)$, $n(\bar{1}\bar{1}1)$, $t(101)$, $r(\bar{1}01)$, $s(203)$, $\alpha(\bar{2}01)$, $x(201)$ only as twin plane, $d(021)$; to these must be added $(\bar{2}21)$ $(=n(\bar{1}11)$ of Fletcher). To convert these to agree with the parameters as chosen by Fletcher (*Min. Mag.* X. 148) the last index must be doubled. Among the many hundred crystals examined only three were apparently simple crystals, and even these on closer inspection showed twin lamellæ. As stated in the original description, there are three twin laws: (1), $a(100)$ is the most frequent, there being both simple and polysynthetic twins; the twinning of the Ceylon crystal is after this law; (2), m (110), as contact, penetrating and polysynthetic twins; (3), $x(201)$, contact and penetrating. Twinning on all these laws may occur in the same crystal, the polysynthetic a and m twins being very frequent.

Zonal structure in the crystals is common. The specific gravity was originally given as 5·006, it being then remarked that this was probably

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too low, owing to enclosures of apatite needles, and to a coating of limonite on the surface of the crystals: a more recent determination gave 5·5 (sp. gr. of the Ceylon crystal =6·025). The cleavage is given as *c*(001), fairly perfect, and *b* and *m* less perfect, the latter being, however, a plane of separation due to the polysynthetic twinning (*cf.* Fletcher). The optical characters are the same as those given by Fletcher: as the first mean line is nearly perpendicular to the *c* cleavage, the optic picture is seen through a cleavage flake. The angle between the first mean line and the vertical crystallographic axis is given as 11° 8′ 18″, in the obtuse angle β. Prof. C. W. Blomstrand's analyses of the mineral (*Neues Jahrb. Min.* I. 89, 1893) gave:—

ZrO_2	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Alkalies	Loss
96·52	0·70	0·43	0·41	0·55	0·10	0·42	0·39=99·52

The associated minerals, obtained by washing the decomposed pyroxenite, are described. L. J. S.

Constitution of some alumino-silicates (S. J. Thugutt, *Neues Jahrb. Min., Beil. Bd. IX.* 554-624, 1895).—The various minerals treated are those related to the artificial soda-nepheline-hydrate, $4Na_2Al_2Si_2O_8{\cdot}5H_2O$: on digesting this body with dilute potassium carbonate solution at a temperature of about 200°, it is split up into a potassium natrolite, $K_2Al_2Si_3O_{10}{\cdot}3H_2O$ and sodium aluminate $Na_2Al_2O_4$; the constitution is therefore represented as $4(2Na_2Al_2Si_3O_{10}{\cdot}Na_2Al_2O_4){\cdot}15H_2O$. Lemberg has suggested that the members of the sodalite group correspond to this soda-nepheline-hydrate in having a soda salt in place of the water, and this is confirmed by the manner in which they are split up by potassium carbonate solution. Sodalite is therefore $8Na_2Al_2Si_3O_{10}{\cdot}4Na_2Al_2O_4{\cdot}8NaCl$, while in nosean and ultramarine NaCl is replaced by Na_2SO_4 and Na_2S_2 respectively. Owing to the somewhat different behaviour of artificial and various natural specimens of sodalite, when digested with calcium chloride solution, three metameric varieties of this mineral are distinguished. When fused soda-nepheline-hydrate is quickly cooled soda-anorthite is produced, this in microscopic sections shows twin lamellæ and an extinction of about 36°; its constitution is represented by $Na_2Al_2Si_3O_{10}{\cdot}Na_2Al_2O_4$. Kaliophilite ($K_2Al_2Si_2O_8 = 2K_2Al_2Si_3O_{10}{\cdot}K_2Al_2O_4$) on digestion with potassium carbonate solution yields a potash mica and free caustic potash: as potash mica has the same empirical formula as this body, it has probably the same constitution, viz. $K_2H_2Al_4Si_6O_{20}{\cdot}H_2Al_2O$ ($=(K,H)_2Al_2Si_2O_8$). This formula agrees with the more basic potash micas, while in the more acid, as represented by Tschermak's phen-

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gite, the group $H_2Al_2O_4$ is omitted. Nepheline, as well as sodalite, is decomposed by long digestion with pure water at an elevated temperature, giving rise to natrolite, sodium aluminate, and some mica or kaolin; for nepheline the constitution is given as $8Na_2Al_2Si_3O_{10}\cdot 4Na_2Al_2O_4\cdot 3K_2Al_2Si_2O_{10}$, which is similar to that of sodalite.

The application of these results is discussed in connection with geological processes and pseudomorphism, especially as regards the alteration of nepheline: from the formula above given for this mineral, it is seen that natrolite, hydrargillite or diaspore, and mica in various combinations could be derived. Hydronephelite is considered to be a mixture of natrolite and hydrargillite, these minerals being derived respectively from the first two groups given in the nepheline formula. L. J. S.

Classification of Ore Deposits (J. H. L. Vogt, *Zeits. f. prakt. Geologie*, 381-399, 1894).—Ore deposits have been variously classified according to (1), chemical and mineralogical composition; (2), outward form; (3), mode of origin, the last being of most importance from a scientific point of view. In the present paper are treated the ores which have originated by magmatic differentiation processes (*cf.* *Abst.* XI. 38); they are grouped as follows:—

I. *Oxide separations.*

a. Separation of chrome iron ore in peridotites.

b. Of ilmenite and titaniferous magnetite in gabbros, nepheline-syenites, &c.

c. Possibly of iron ores (without titanium) in granites, &c.

II. *Sulphide separations.*

a. Separation (?) of copper sulphides in peridotites, *e.g.* in Tuscany, N. Norway, &c.

b. Of nickel-bearing pyrrhotite in gabbros, &c.

III. *Metallic separations.*

a. Separation of platinum metals in peridotites.

b. Of nickel-iron in various basic rocks.

Under I. *a*, numerous analyses of peridotites are quoted, and it is shown that they contain on an average 0·20 – 0·35 per cent. of Cr_2O_3, which exists as picotite, chromite, and to a smaller extent is present in various silicates; ilmenite, apatite, etc., are exceptional in such rocks. A typical example of chromite deposits, separated by differentiation processes in peridotites, is that of Hestmandö-Feld (N. Norway). The rock here con-

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sists mainly of olivine and enstatite, the relative proportions of the two minerals being very variable; picotite and chromite occur, and as these increase, the rock passes through chromite-saxonite and -dunite, into pure chromite, such concentrations occurring in the interior of the masses. In the several masses of serpentine of Norway (*e.g.* Röros) a greater or less concentration of chromite is found. In both the gabbros, &c., and in the peridotites it is noticed that both the oxide and sulphide types of separation occur. L. J. S.

Mineralogical and Chemical Composition of the Dune-sands of Holland (J. W. Retgers, *Neues Jahrb. Min.* I. 16-74, 1895). It is usual to suppose that easily cleavable and decomposable minerals do not occur in sands; such is, however, not the case, as they are found in grains quite as large as those of the more resisting minerals. Sea sands and dune sands are compared, and the action of the wind and sand blasts is pointed out. The grains of dune-sand are only rarely less than a minimum size of ¼ mm. diam., and there seems to be some relation between the size of the grains and the force of the wind. The minerals found in the dune-sands of Holland are, in order of frequency, quartz, garnet, augite, hornblende, tourmaline, epidote, staurolite, rutile, zircon, magnetite, ilmenite, orthoclase, calcite, apatite, and, less frequently, plagioclase, microcline, cordierite, sphene, sillimanite, olivine, kyanite, corundum and spinel. Some of the grains show crystal faces; especially zircon, and less often spinel, magnetite and garnet. Owing to the fact that the density of minerals is subject to variation (due to isomorphous replacement and to enclosures) it is not easy to separate the individual minerals by means of heavy solutions and fused salts. The minerals were therefore separated into the following groups:—

Density.		Per cent.
2·5—2·6	Quartz-orthoclase group	2·5
2·6—2·7	Pure quartz ,,	85·0
2·7—3·0	Quartz-calcite ,,	7·5
3·0—3·3	Amphibole ,,	1·5
3·3—3·6	Pyroxene ,,	1·0
3·6—4·2	Garnet ,,	2·4
4·2—4·5	Rutile ,,	0·05
4·5—4·8	Zircon ,,	
4·8—5·2	Iron ore ,,	0·05

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The heavy solutions used were Sonstadt's (Thoulet's), methylene iodide, in which is dissolved iodine and iodoform (specific gravity 3·6—3·65), and fused silver- and thallium-nitrate (*cf.* *Abstr.* Vol. XI. p. 44). Under the microscope the grains were examined, whole and crushed, in liquids of varying refractive indices. The optical characters, microchemical reactions, and mode of detection of each mineral are treated at some length, and suggestions added as to their origin. Each of the above groups was also analysed quantitatively. It is probable that if large quantities of the sand could be dealt with, rare elements would be found, as the minerals containing these are characteristic of granites and gneisses. Remarks and suggestions are made as to similar work which might be done with river and sea sands, and its importance in connection with geology and sedimentary rocks. A short review of previous work in this direction is given. L. J. S.

Some Dyke-rocks in the Christiania District.—W. C. Brögger has recently published a valuable instalment of his studies on the eruptive rocks of the Christiania district (*Vid.-Selsk. Skrifter, Math.-Natur. Kl.*, 1894, No. 4) dealing with certain rocks which occur mainly in the form of dykes and minor intrusions. In former memoirs he has shown how the whole of the eruptive rocks of the district may be regarded as derived by successive processes of "differentiation" from one initial magma. He now calculates the composition of that magma from the analyses of the various rock-types derived from it, and finds that the figures so found (I.) agree very closely with those for the type Nordmarkite, which is the most widely developed of the several rocks, (II.) the special chemical characteristic, which runs through the whole group of rocks, being the remarkable richness in soda.

	I.	II.
SiO_2	64·2	63·52
Al_2O_3	17·2	17·32
Fe_2O_3 (FeO, and MnO) ...	3·6	3·63
MgO	0·8	0·78
CaO	2·0	1·35
Na_2O	7·0	6·95
K_2O	4·6	5·31
H_2O, TiO_2, etc.	0·6	1·12
	100·0	100·48

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The rocks specially treated in this paper are fine-grained to compact, greenish rocks, usually rich in ægirine. The first type, designated *Grorudite*, is a kind of ægirine-granite-porphyry, with or without conspicuous porphyritic felspars. These felspars are microcline and albite, often in microperthitic intergrowth; other porphyritic elements are ægirine, a peculiar hornblende, etc.; the ground-mass is of potash-felspar and albite, ægirine, and a certain amount of quartz. The microcline has usually the "moiré structure" rather than the familiar cross-hatching. The hornblende is a soda-bearing variety distinct from both barkevicite and arfvedsonite, having an extinction angle ($c\,\gamma$) of 30° to 60°, and a pleochroism formula $\beta > \gamma > \alpha$ (reddish colours): it is here named catoforite. The chemical composition of grorudite, the mean of four examples, is given under column III.:

	III.	IV.	V.	VI.
SiO_2	70·19	64·92	56·58	45·18
TiO_2	0·29	—	—	—
Al_2O_3	11·96	16·80	19·89	28·31
Fe_2O_3	4·94	3·62	3·18	6·11
FeO	1·18	0·84	0·56	—
MnO	0·48	0·40	0·47	—
MgO	0·16	0·22	0·18	1·45
CaO	0·65	1·20	1·10	4·62
Na_2O	5·73	6·62	10·72	11·17
K_2O	4·06	4·98	5·43	5·95
H_2O	0·80	0·50	1·77	1·14
	99·94	99·60	99·88	98·93

it compares closely with the soda-granite with which the grorudite dykes are associated, having, however, more ferric oxide and alumina. Associated dykes consist of an aplite which, on the other hand, is poorer in iron: this and the grorudite are regarded as complementary products of differentiation of the soda-granite-magma.

The next type, named *Sölvsbergite*, is a less acid rock than the preceding, and has little or no quartz; in other respects it is mineralogically very like the grorudite. Structurally it is somewhat different, being rarely porphyritic and approaching some trachytes in its characters. It is a true dyke-rock ("hypabyssal" rock). The corresponding volcanic or surface rock is ægirine-trachyte; the corresponding abyssal or plutonic rock is nordmarkite. A chemical analysis gave the figures under IV.

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There is somewhat more ferric oxide and less alumina than in the nordmarkite, to which these dykes belong, the kind of differentiation being thus similar to that evinced by the grorudites. Further, there are associated with the sölvsbergite dykes others of a complementary type (lindöite).

Another type of dyke-rock in the district answers to the *Tinguaite* of Rosenbusch, and is of still more basic composition. In this not only is quartz wanting, but nepheline appears with some abundance. The chemical composition is indicated in column V. This rock is connected with the nepheline-syenite of the district, and stands related to that rock just as the grorudite does to the soda-granite and the sölvsbergite to the nordmarkite. Here, too, are found dykes of complementary composition ("syenite-aplite"). The three types of dyke-rocks specially dealt with in this memoir thus appear as modifications in a definite direction of the various plutonic magmas. Perhaps some clue to the mode of differentiation which produced the partial magmas is furnished by the observation that the individual dykes sometimes grow somewhat richer in ferric oxide and poorer in alumina towards their edge. By going to other districts the author supplements the grorudite-sölvsbergite-tinguaite series by another, more basic type, which he styles *Sussexite*. This is represented by Kemp's rock from Beemerville in New Jersey (analysis VI.), and approximately by other examples. A. H.

Serpentine as an original igneous product.—We have already noted (*Min. Mag.* Vol. X. p. 34) a memoir by E. Weinschenk dealing with the serpentine-rocks of the eastern Central Alps. In that he concluded that these rocks were in every case altered igneous intrusions, having been for the most part rocks rich in non-aluminous pyroxene, now converted into serpentine with the "Gitterstructur." More recently this author has come to very different conclusions concerning the same rocks (*Abhand. k. bayer. Akad. Wiss.* II. Cl. Vol. XVIII. part 3). He still finds the serpentine-rocks incontestably of igneous origin, but he now believes that much of the mineral serpentine in them is original. The least altered type, to which he gives the name *stubachite*, consists essentially of olivine and serpentine with some chrome-spinel, and only locally a considerable amount of diallage. It is a peridotite, only exceptionally graduating into a pyroxenite (diallage-rock). The serpentine is antigorite in flakes, which are often interposed in the olivine with a definite arrangement, namely, in two directions parallel to the brachydome (011) of the latter mineral. The author regards this as an original intergrowth of olivine

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and antigorite. In most of the rocks the olivine and (to a less extent) the diallage have been altered, so that original and secondary serpentine together make up most of the mass. The reasons given for regarding the antigorite as an original product from the igneous magma do not seem to be perfectly convincing, but the phenomena described by the author are sufficiently remarkable to deserve careful consideration.

A. H.

A perofskite-magnetite-rock from Brazil.—Aggregates very rich in iron ores, occurring as peculiar facies of basic igneous rocks, have already been described from Brazil by O. A. Derby, the "jacupirangite" type (a magnetite-pyroxenite) being of special interest. More recently E. Hussak has drawn attention to a remarkable mass occurring at Catalao in the state of Goyaz (*Neu. Jahrb. für Min.* 1894, Vol. II. p. 297). It consists essentially of magnetite and perofskite. The former is partly in little crystals 1 to 2 mm. in diameter, partly in irregular patches and veins wedged in between the crystal-grains of perofskite. The latter, making up the greater part of the rock, are about 2 mm. in diameter, and show in a thin slice the usual high refringence and birefringence of the mineral. For the most part, however, the perofskite is decomposed to a dark, reddish-brown earthy substance, which proved to be pure titanic acid (perhaps anatase). A. H.

Mica-Hypersthene-Hornblende-Peridotite from Bengal (T. H. Holland, *Records Geol. Survey of India*, XXVII. p. 142, 1894). Mention is made of previously recorded mica- and mica-hornblende-peridotites, amongst which the scyelite of Caithness is the nearest approach to the present rock from Mánbhúm. According to the essential and primary constituents, in their approximate order of proportion, the rock may be described as an olivine hornblende-biotite-hypersthene-augite-rock; apatite, magnetite, pyrites, pyrrhotite and labradorite also occur. The ophitic plates of biotite, which is the last formed of the primary constituents, often determine the fracture of the rock by their cleavage; a fractured surface showing the usual lustre-mottling. The magnetite and plagioclase are of secondary origin. The sp. gr. of the fresh rock is 3·234. L. J. S.

Phosphatic Mica-Peridotites from Bengal. (T. H. Holland, *Records Geol. Survey of India*, XXVII. p. 129, 1894).—The so-called "mica-traps" occurring as dykes in the coal measures of Lower Gondwana age of various parts of the Bengal coal fields, prove to be ultrabasic rocks,

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often with large amounts of apatite (up to 11·4 per cent.) in slender prisms. Other original constituents are olivine and biotite, as well as anthophyllite, augite, and iron ores (magnetite, chromite, ilmenite), which in various proportions give olivine-mica-apatite-rock, mica-olivine-anthophyllite-augite-rock, &c. Secondary minerals are serpentine, magnetite, perofskite, and rhombohedral carbonates (containing magnesium). The structure of the rocks varies from coarse holo-crystalline at the centre of the dykes to compact at the margins. The sp. gr. of the least altered rock is 2·99, being less in the much decomposed yellowish rocks. The anthophyllite appears to be optically negative, and the pleochroism is:—

a = a, straw-yellow.
b = b, claret-red. Absorption, b > c > a.
c = c, gamboge-yellow.

These rocks are somewhat similar to the diamond-bearing peridotite of South Africa, which they also resemble in their mode of occurrence and age. L. J. S.

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THE MINERALOGICAL MAGAZINE

AND

JOURNAL

OF THE

MINERALOGICAL SOCIETY.

No. 51. OCTOBER 1896. Vol. XI.

On Homogeneous Structures and the Symmetrical Partitioning of them, with application to Crystals.

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[Read November 19th, 1895.]

AT the outset we have to consider what constitutes homogeneity of structure.

First, it may be noted that it is not to be confounded with *structureless homogeneity*.

The completest homogeneity conceivable is presented when at *every geometrical point* in space the qualities are the same; but when this is the case, structure is absent, and no property can be displayed depending on differences of any kind which enable us to distinguish one point from another, however infinitesimal the distance separating the points compared. Homogeneity of structure consists, not in the same qualities being presented at every geometrical point of a body, but in the similar repetition of the same qualities or forms throughout it.

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In Thomson and Tait's treatise on Natural Philosophy we read, "A body is called homogeneous when any two equal, similar parts of it, with corresponding lines parallel and turned towards the same parts, are undistinguishable from one another by any difference in quality;" but this definition, when applied to a homogeneous structure, cannot be other than empirical and not mathematically precise, its truth depending on the tests applied not being refined enough to detect ultimate discontinuity of constitution of the structure.[1] It may be said, as applied to such a structure, to describe an apparent property rather than to lay down a geometrical definition. The writer has endeavoured to frame a definition of homogeneity of structure which shall be mathematically exact, and free from any needless limitation, and recently propounded the following:[2] "A homogeneous structure is one every point within which, if we regard the structure as without boundaries, has corresponding to it an infinitude of other points whose situations in the structure are precisely similar, so that all of the infinite number of geometrical point-systems respectively obtained by taking all similarly situated points are regular infinite point-systems, defined by Sohncke as systems of points such that the arrangement about any one of these points of the rest of the points of the system is the same as it is about any other of them."[3]

It may be remarked in this connection that the conception of a system of points or atoms which repeats itself in the way indicated presented itself independently to both Sohncke and Wiener.[4]

Here are some models which I have constructed to show some of the least complicated types of homogeneous structure of the cubic system, and which will, I hope, make my position clearer; and in reference to them I may say that my mind has been exercised in attempts to portray the nature of the repetition which constitutes homogeneity of structure in the most general way possible, and especially to avoid anything which seems to imply atomicity, proof of the existence of which must, it would appear, be sought elsewhere than in the geometry of crystals, *i.e.* of homogeneous structures.

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[1] Fedorow cites some evidences of discontinuity of structure of crystals. See *Theorie der Krystallstruktur* in *Zeitschr. für Kryst. &c.* XXV. p. 116. Comp. Thomson and Tait, II. p. 216.

[2] *Zeitschr. für Kryst. &c.* XXIII. p. 1.

[3] Sohncke's *Entwickelung einer Theorie der Krystallstruktur*, p. 28. Those kinds of repetition in space the repeating parts of which have some dimension infinite, are not included in this inquiry.

[4] Comp. Wiener's *Grundzüge der Weltordnung*. Leipzig, 1869. Atomlehre, p. 82.

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With this purpose before me, I have, in devising my models, avoided the use of particles or spheres, and have placed a quite irregular body, a hand,[1] in the positions appropriate for showing the kind of repetition characteristic of a given type.

This model (a cubic element of which is shown diagrammatically in fig. 1) gives a certain very regular type of cubic symmetry, that which is marked $7a_1$ in the lists of homogeneous structures to be found in the memoir above referred to.[2] It belongs to Class 31 (dodecahedral hemihedry) in Sohncke's list of 32 classes of crystal symmetry.[3] The structure contains left hands as well as right hands, because it is one of those that are identical with their own mirror-images, and consequently made up of parts enantiomorphically related. It is formed of a number of similar groups of the kind shown, the cubes containing which are fitted together to fill space symmetrically.

In the actual model each such cubic element is composed of eight *cubelets*, the edges of which are formed of strips of wood meeting at the corners of the cubelet, and the latter having also one of its four diagonals occupied by a strip of wood on which three hands are hung symmetrically.

Thus each cubelet contains three of the 24 hands found in a single element, four alternate cubelets being similarly occupied by right hands, the remaining four by left hands. The entire structure is therefore built up of cubelets of two kinds, with their respective triads of hands.

The eight single diagonals of the eight cubelets of an element meet in a point at its centre.

The cubic partitioning thus indicated is, however, not essential, and is to be regarded as mere scaffolding, and as having fulfilled its object in keeping the hands in their places, and in enabling us better to perceive the nature of their arrangement; *indeed, the type of homogeneity is expressed in a more general manner when there is no partitioning at all.*[4]

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[1] Comp. Fedorow, *Zeitschr. für Kryst.* XXV. p. 115. The employment of hands was suggested to me by Prof. Miers; its advantages are that the use of so familiar an object greatly facilitates a clear perception of the nature of the arrangement, and that the shape is so exceptional that no one can be led to imagine it to be a necessary feature of any type.

[2] *Zeitschr. für Kryst.* XXIII. p. 44.

[3] *Zeitschr. für Kryst.* XX. p. 467.

[4] This is true of all the types. The same homogeneous structure can, in most cases, be partitioned in a manner compatible with the preservation of its homogeneity and symmetry *in an infinite number of ways*. The cubic partitioning resorted to in the case under consideration is a very arbitrary one, and a structure of the given type need not have any characteristics corresponding to the *exceptional* symmetry which this kind of partitioning produces.

As we shall see presently, there are cases of homogeneous structure in which *no*

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In the case before us, the edges of the cubelets are digonal axes of rotation of the structure, *i.e.* when the structure is turned through 180° about one of them, all its parts in the new position coincide with all its parts in the old. The positions of the planes of symmetry of the structure, as well as those of the various axes, are readily traceable when a number of composite cubic groups of the kind described are stacked together.

The right hands are distributed homogeneously, and so are the left hands, and, in obedience to the definition above given, any set of similar points, *e.g.* the tips of the thumbs, or the tips of the first fingers of either right hands or left hands, form a Sohnckian point-system. If we take corresponding points of both right and left hands, we obtain the double point-systems of Fedorow. The single point-systems traceable in this type are those described by Sohncke as No. 54; it is easy to see that all the points in any one of them have the fundamental property of a regular infinite point-system; they bear identically the same relation to the infinite structure considered without reference to the horizon, or the north pole, or indeed anything other than the homogeneous structure itself.

One of the simplest possible examples of this type of structure will be obtained if we make a stack of similar bricks in the following way; and to make the description simpler, we will employ bricks whose width and thickness are respectively half and quarter of the length.

Stand two bricks on end opposite and parallel, with a space between them of the width of a brick, the two thicknesses and the space together thus making up the length of a brick.

In the space lay a brick flat, so as to project the thickness of a brick on each side beyond the two first placed.

On the projecting ends of this brick stand two bricks on edge, with their overhanging ends even with the faces of the two first placed.

Finally, place a brick flat directly over the middle one, with its ends resting on the two last placed.

The outline of the pile thus formed will be a cube, except that a cube-shaped vacancy will be left at each of the eight corners. There will also be a cubic cell left in the middle.

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kind of partitioning *into single units* (*i.e.* not of two kinds which are enantiomorphs) is possible *which does not impair the symmetry and alter the type of homogeneity.* (See p. 132 and $2b_1$ and $6b_2$ in table on p. 135).

Some suggestions for the classification of the different kinds of *symmetrical* partitioning possible will be made presently.

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Stack together a number of cubic elements of this kind similarly orientated, with the cubes of succeeding layers directly over one another. The homogeneous structure obtained is an example of the type above given.

As the outside faces of the bricks of each cubic element coincide with the faces of those in contact with it belonging to the adjoining elements, the stack may be regarded as composed of pairs of bricks, each pair consisting of two bricks placed face to face. No change of type will therefore be involved if, instead of pairs of bricks, single bricks of double the size are used, *i.e.* such as have width and thickness equal, and each equivalent to half the length. Each double brick will then fill the space previously occupied by two of the thinner ones.

Other types of homogeneous structure also of the cubic system are represented by these remaining models, composed of hands appropriately arranged.

Thus we have:—

Type 7, a representative of Class 32, the tetartohedral cubic (an element of this structure is represented by fig. 2). Of the eight cubelets which compose the element, four are those containing right hands (or left hands), and the remaining four are empty.

Type $7b_1$, a representative of Class 30, tetrahedral hemihedry (an element is represented by fig. 3). Of the eight cubelets composing the element, four contain both right and left hands symmetrically placed, and four are empty.

Type 12, a representative of Class 29, the gyrohedral cubic (an element is represented by fig. 4). The eight cubelets composing the element, all contain right hands or all left hands.

Type $12a_1$, a representative of Class 28, the holohedral cubic (an element is represented by fig. 5). The eight cubelets comprising the element all contain both right hands and left hands.

The simplest possible example of a structure of the last-named type is presented by a cubic partitioning of space whose cells *are empty*. We have too an extremely simple example of this type in a cubic Raumgitter.

Here, too, are some types of structure which are most conveniently constructed by packing close together cells which are respectively dodecahedra and cubo-octahedra, but as before the cellular construction is to be regarded as mere scaffolding.

Type 6. This, like type 7, is a representative of Class 32, the tetartohedral cubic (an element contained in a dodecahedral cell is represented by fig. 6). This type can also be built up of cubelets, but there will be a larger number of empty ones than in the former cases.

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Type 10. This also, like type 7, is a representative of Class 32, the tetartohedral cubic (an element contained in a cubo-octahedral cell is represented by fig. 7).

If cubelets with a single diagonal are employed to build up this type, they must each contain three right hands or three left hands appropriately placed, cubelets which have a common diagonal being everywhere found similarly orientated.

The element contained in the dodecahedral cell of type 6 is precisely of the same kind as that contained in the cubo-octahedral cell of type 10. Similar points form, in both cases, 12-punkters of Sohncke.

Cubelets with a single diagonal, of the kinds above described, can also be employed to construct the less-regular types of structure of the cubic system.

In the memoir referred to[1] I have made an investigation of all the possible types of structure which fulfil the definition given above. The result shows that all homogeneous structures have a general symmetry which is strictly paralleled by the symmetry of crystals. And, while it is true that the definition laid down does not express any limitation regarding the relative orientations of the similar parts[2] whose likeness constitutes the homogeneity, much less require the orientations to be identically the same, as is the case with some of the older definitions of homogeneity, we discover that similar portions of a homogeneous structure always have a definite number of symmetrically related orientations, depending on which among the 32 classes of crystal symmetry the structure selected belongs to.

And this number is that of the different orientations of the ideal crystal form which can be made and give coincidence of outline. It is therefore in some but 1; in others 2, 3, 4, 6, 8, 12, or 24, as the case may be.

The relation of the orientations of similar parts just referred to *should not, therefore, be made a matter of definition, but of proof.* If a likeness of parts obeying the definition which I have given existed which did not give the symmetrical relative orientations referred to, it would notwithstanding be an example of homogeneity of structure; but, in fact, as I have just intimated, there is no exception, the only case where there is homogeneity without symmetrically related orientation of similar parts being that of structureless homogeneity.

[1] As corrected in some few particulars in an article in the same journal, Vol. XXV. p. 86.

[2] By similar parts is meant parts similarly related to the whole.

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There is a more uniform quite universal property of homogeneous structures, which may be expressed in much the same words as those of Thomson and Tait's definition quoted above.

Thus, such a structure can always be regarded as made up of equal, similar, sameways-orientated parts, which are undistinguishable from one another by any difference in quality.[1]

Each of the parts thus related will consist of an integral number, large or small, of space-units[2] of the structure of some kind or other. In the case of a structure with anorthic symmetry, it may comprise but one space-unit only. The distances between corresponding points of two such adjoining parts will be those between the corresponding points of some two contiguous or more or less widely separated space-units *whose orientation is the same.*

The outlines of the parts thus related will generally not constitute a partitioning which can represent any possible natural partitioning of crystals into chemical molecules, or into crystal molecules (if there be such entities distinct from chemical molecules); for, except in a few particular types of cases, the partitioning arrived at in this way will be quite arbitrary, and be incompatible with some of the coincidence-movements (Deckbewegungen[3]) of the structure, and therefore destructive of a portion of its symmetry, and will effect a change of its type.

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[1] Fedorow says, "Das Resultat der Beobachtungen kann auch dahin gedeutet werden, dass die krystallinisch-homogene Substanz aus gleichen und gleich-orientirten (d. h. sämmtlich in paralleler Lage geordneten) Theilchen besteht, welche zusammen genommen den Raum lückenlos ausfüllen."—*Zeitschr. für Kryst.* XXV. p. 117.

[2] The three necessary properties of a space-unit are—(1) it is continuous; (2) it contains every kind of point of the structure (*i.e.* every kind of standpoint from which the structure can be regarded); (3) all the points in it are differently related to the structure as a whole. See *Zeitschr. für Kryst.* XXIII. p. 38.

[3] The following is Sohncke's definition of a coincidence-movement (*Deckbewegung*):—

Suppose a regular infinite point-system (see p. 120 above) to be made rigid, and moved bodily out of its original position. The positions originally occupied by the points of such a system then collectively furnish a point-system which is congruent with the moved system, and which, to distinguish it from the *moveable system*, may be called the *fixed* system.

If now any point of the moveable system be selected, and placed to coincide with any point whatever of those of the fixed system, it is, owing to the congruence of all *Linienbündel*, always possible to bring the two systems to coincidence.

The movement which the moveable system executes in order to pass from one position of coincidence with the fixed system to some other position of coincidence, is called a *Deckbewegung*.

Such Deckbewegungen can be partly parallel translations, partly rotations or screw movements about certain axes definitely placed in the fixed system.

The Deckbewegungen possessed by any particular system will depend on the properties of the system, and indeed the different kinds of point-systems may be

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The property referred to is therefore of no great importance as regards the ultimate structure of crystals, although it may possibly aid our conception of the connection between homogeneity of structure and some physical properties.[1]

The definition above given is, as we have seen, not limited in its application to point-systems or assemblages of particles; it may be obeyed by any kind of structure, whether material or merely geometrical, whether filling space or continuously ramifying through it, or distributed through it in discrete patches. It may, too, be obeyed by structures whose parts are in motion, provided the similarity extends to the movement of similar parts; but the similar movements need not be simultaneous.[2]

The number of different types of symmetrical arrangement presented by homogeneous structures is 230;[3] and these types, as we have said, fall into 32 classes, whose general symmetry is of the 32 kinds proper to crystals.

Such an array of possible types may well alarm the crystallographic student, and lead him either to quit the subject of homogeneous symmetry in despair, or to beat about for some pretext which shall justify the exclusion of some of these types, and bring the number available for crystals down to a smaller figure.

I deprecate the latter course, unless the grounds for it are fully adequate; otherwise the very types we exclude may turn out after all to be those which are most suggestive in connection with crystal properties.

The course which seems to me more scientific, and I may add more hopeful, is to seek to become acquainted with the principal features of homogeneous structures generally, *and especially with the numerous geometrical properties which they possess in common.*

The models which I have made are, I think, calculated to give some material help in this direction; even a cursory glance at them reveals such intimate relations and similarities between types which eminent authorities say we may reject for crystallographic purposes, and others

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distinguished according to the Deckbewegungen which are proper to them, so that the different sets of Deckbewegungen presented serve as the ground of the classification of the regular point-systems. (See *Entwickelung einer Theorie, &c.* p. 28. Compare Bravais, "Sur les Systèmes formés par des points distribués régulièrement," *Journ. de l'Ecole Polytechnique, Cahier*, XXXIII. p. 57.)

[1] See below, p. 127.

[2] They may resemble the rhythmically related movements of *combined figure skating.*

[3] This number agrees with the total number of single and double point-systems as ascertained by Fedorow and Schönflies independently.

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which they say we may retain, as will at least make us examine very closely, and indeed suspiciously, the grounds on which they consider themselves authorised to discriminate.

I allude more particularly to Fedorow's attempt to select from among the types of homogeneous structure those which are possible for crystals, and to determine the shapes of their ultimate units,[1] in reference to which I cannot but express my regret that so eminent an authority on crystal structure should give the weight of his name to what appear to me to be *a number of wholly untenable limitations*.

Fedorow says that the result of observations of the properties of crystals may be summed up in the proposition that the homogeneous crystal-substance consists of similar, sameways-orientated parts which, taken together, fill space without interstices,[2] and proceeds to argue that some of the 230 types of homogeneous structure are incapable of being thus divided, and must therefore be regarded as impossible for crystals.[3] But is this so? It has already been pointed out above that every homogeneous structure, *without exception*, can be regarded as made up of equal similar, sameways-orientated parts, which are undistinguishable from one another by any difference in quality, and there does not appear to be any reason why a structure possessing this property should not fulfil the experimental requirements of crystal-structure *even in cases where the sameways-orientated parts are merely geometrical ones, the existence of whose boundaries lowers the symmetry of the structure as a whole and alters its type*, and which do not, therefore, represent any separable units (molecules or other).[4]

We have indeed to ask ourselves continually in connection with this and the other contentions of Fedorow, contained in the same treatise, what significance he attaches to his partitioning of a crystal structure? Is it suggested that when a crystal dissolves, its parts will under any circumstances retain shapes which, if fitted together, fill space, or, to put it more precisely, that the solid angles and edges of the cells are none of them vacuous or structureless in the unbroken structure, but always occupied by matter which, when the structure breaks up, can retain its situation relatively to other matter belonging to the same cell? Such a

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[1] Fedorow's *Theorie der Krystallstruktur. Mögliche Strukturarten. Zeitschr. für Kryst.* XXV. p. 113.

[2] *Zeitschr. für Kryst.* XXV. p. 117.

[3] *Ibid.* See especially p. 218.

Cases of this kind are presented by types 3 and 4 in my list. *Zeitschr. für Kryst.* XXIII. p. 11. Compare below, pp. 128 and 135.

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proposition is so unlikely that to state it is almost to refute it. Certainly we cannot, until evidence is forthcoming, assume that there is any truth in it.

But if, as is then almost certain, the partitioning into cells of a definite outline capable of filling space is, in the case of crystals, *a mere geometrical fiction*, what stress can be laid on the relative inclinations of the plane-faces of the cells,[1] or how can re-entrant angles be argued to be unlikely, or indeed what significance is there in the cell-walls having plane-faces at all?

If a particular partitioning has no strict counterpart in a crystal, but simply expresses the nature of its divisibility into units or molecules in a general manner, the presence of a re-entrant angle in a cell wall would merely represent that the outline or boundary of one composite unit or molecule fits into that of an adjoining one like the parts of a carpenter's "dovetail," or like a tenon into a mortise, a conception by no means startling or improbable when taken in as general a sense as possible.

We cannot, therefore, concur with Fedorow in his rejection of those asymmorphous types which cannot be partitioned into similar cells with similar contents, whose *outline*[2] *displays the complete symmetry of the entire structure*, or accept his reasons for regarding as unlikely for crystals cases where the partitioning into plane-faced cells gives either (*a*) abnormal (anomale) parallelohedra, *i.e.* parallelohedra whose form is such that no kind of homogeneous deformation reduces them to the most symmetrical forms of crystal symmetry,[3] or (*b*) re-entrant angles between the plane walls of a cell,[4] or (*c*) cells whose external boundaries are similarly orientated, while the contents of the cells are not.[5]

It is true that Fedorow's classification of homogeneous structures under three heads—symmorphous, hemi-symmorphous, and asymmorphous systems—marks geometrical differences whose nature is thus

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[1] Fedorow distinguishes "normale" and "anomale" parallelohedra (see below).

[2] Comp. Fedorow, *Zeitschr. &c.* XXV. Note*, p. 147.

[3] *Ib.* p. 132.

[4] *Ib.* p. 133.

[5] Fedorow calls these "extraordinär," those whose contents and outlines are alike sameways-orientated "ordinär" (see p. 135).
The suggestion made by this author (p. 146) that cases of the "extraordinären" kind are unlikely, because it is inconceivable why the contents of the cells should be differently orientated, does not help his contention, because, if there is this difficulty in accounting for various orientations of the composite elements of a mass, *there is also the same kind of difficulty* in accounting for the similar parts of any such element being put together with their orientations various, and the latter is an essential condition in most homogeneous structures.

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appropriately indicated, and that his other distinctions are also based on geometrical facts; but this does not strengthen his position so long as he fails to bring forward any evidence which is even plausible that any one of the classes of a highly specialised nature which he discriminates is more likely than another to be present in crystals.[1]

Instead of dwelling on differences between the various kinds of plane-faced cells—an investigation which may or may not ultimately prove to be of any importance—we ought, as it seems to me, to strive after some altogether broader treatment of the subject, which will classify the various kinds of partitioning possible in a perfectly general manner, without arbitrarily rejecting any.

Reasons are not wanting for undertaking an investigation of this sort.

Thus the fact that bodies which form crystals are capable of passing to a liquid state and back again to the crystallised condition *without breaking up into their constituents*, and the evidence we often have of the survival in the liquid of some portion of the symmetry of arrangement of parts prevailing in the solid, *notably in the cases of those bodies which rotate the plane of polarisation*, lead us to conclude that crystallised matter can be broken up into particles or units which are all alike, and each of which has parts or properties that have some definite arrangement relatively to one another.[2]

In some cases there is evidence of the survival in the dissolved crystal of two kinds of arrangement which are enantiomorphous, *e.g.* racemic compounds can mechanically or otherwise be shown to be composed of two isomers which are respectively right handed and left handed, but otherwise alike.

In the light of such facts as these the subject appears to be interesting, and likely to prove at least suggestive; the remainder of this paper is, therefore, devoted to an attempt to indicate broadly the lines on which it may be dealt with.

The symmetrical partitioning of homogeneous structures.

The existence of a homogeneous structure whose stability is such that it withstands internal or external forces, implies the existence of ties or bonds of some sort which keep it together, and preserve, or continually

[1] There does not indeed appear to be any evidence that the divisions of Fedorow's classification are at all traceable by the experimental facts at present known to us regarding crystals.

[2] This is true, whether there is any such thing as a crystal molecule distinct from a chemical molecule or not. There does not, it may be remarked, appear to be any adequate evidence of such a distinction.

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restore its form, and the arrangement of these ties will conform to the definition of homogeneity. And in the case of a structure identical with its own mirror-image, the system they form will also possess the latter property.

Any *uniformly applied* disintegrating force will, as a consequence of the symmetry, break the ties, whatever they may be, in a uniform manner, so that the loosing of any given tie will be accompanied by the loosing of all ties similar to it throughout the structure; and if the disintegration leaves some ties intact, these also will be such as were similarly placed in the undissolved structure, *i.e.* the survival of any given tie will involve the survival of all ties similar to it in nature and situation. The application of a uniformly applied disintegrating force will not, therefore, produce the kind of partitioning above referred to, which is incompatible with the coincident-movements (Deckbewegungen)[1] of the structure.[2]

1. If the breaking of the ties does not bring about the absolute fluidity of any portions of the structure, but merely its separation into parts of relatively small magnitude, whose united bulk is that of the space originally occupied by the structure,[3] the latter will come to consist of a collection of fragments, either of one kind only, or of a definite number and variety of different kinds, continually repeated throughout space, and *of such form or forms as will, when properly fitted together, fill space without interstices.*

2. If, however, any parts of the structure become absolutely fluid or are vacuous, while other parts remain rigid, *i.e.* contain undissolved ties, the effect of the uniform loosing of some of the ties accompanied by disturbance will be to reduce the mass to a collection of rigid fragments, either all of the same pattern, or of a limited number of patterns, but not capable, as in the former case, of completely filling space; and they will be interspersed through the structureless fluid, that is if such a fluid, and not a vacuum, occupied in the dissolving structure the rest of space.[4]

Now if we confine our attention to simple structures only, *i.e.* to those whose ultimate fragments or particles, when liquefaction ensues, are all

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[1] See Note 3, p. 125. [2] See page 125.

[3] Expansion or contraction of the parts of the structure is neglected.

[4] If the ideas generally held respecting the nature of matter are substantially correct, this, and not the previous alternative case, will be that of actual partially liquefied homogeneous matter, *i.e.* of liquefied crystals the ultimate parts of which retain some kind of stable structure. Cases in which the fragments are not all of the same pattern are probably furnished by crystals containing "water of crystallisation," and by double salts.

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similar,[1] we easily see that although the situation of the boundaries of these fragments is, in the case of any given type of homogeneous structure, quite indeterminate so long as the precise nature of the structure is unknown, we are able to range the infinite number of ways in which the given type is divisible symmetrically into similar fragments in certain distinct classes; and this applies whichever of the two alternative kinds of disintegration above defined obtains.

For in the case of each type all the infinite number of possible ways in which such a subdivision can take place can be classed in groups *according to the coincidence-movements (Deckbewegungen) found surviving in each of the isolated similar fragments or parts of the disintegrated assemblage.* And taking into account the possession by some of the structures of the additional property of identity with their own mirror-images, we may further distinguish cases in which each fragment is identical with its own mirror-image from cases in which the fragments are enantiomorphs, and consequently half of them right handed and the other half left-handed.[2]

Thus, for example, if a certain type of homogeneous structure contains a single set[3] of digonal axes of rotation, and a single set of trigonal axes of rotation, we can discriminate cases in which each fragment has a digonal axis and no trigonal axis from those in which there is a trigonal and no digonal axis, and both these again from those in which the fragment when isolated has no axis at all.

As to cases where there is identity with the mirror-image. If a type of homogeneous structure contains either centres of symmetry (inversion centres), or planes of symmetry, on the two sides of which parts enantiomorphically related are *directly opposite*, or centres about which parts thus related are arranged as in types 63c and 64c in my list,[4] *we can*

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[1] That is, either identically or enantiomorphically similar. Comp. cases of racemic compounds referred to above, p. 129.

[2] Cases are conceivable in which the enantiomorphic property of fragments is manifested only when they are considered with respect to the unbroken structure; they may themselves, considered alone, be destitute of this property. In other words, groupings which are identical with their own mirror-image, and all identically alike, may occupy two different sets of enantiomorphically similar situations in a structure. Indeed, the groupings which survive in the liquid state may, when considered alone, apart from the structure, have *any additional elements of symmetry which are compatible with those which they already possess as parts of the structure.*

[3] Axes are of the same set when their relation to the entire system of axes found in the structure is the same, *and that whether they can be brought to coincidence or not.*

[4] See *Zeitschr. für Kryst.* XXIII. p. 59.

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have either kind of fragment produced by disintegration, that which is identical with its own mirror-image, or that which occurs always in two sorts, a right handed and a left handed. If, however, neither of the elements of symmetry just referred to is present, but the enantiomorphic correspondence of parts is solely due to the existence of those planes of symmetry (Gleitebenen) on the two sides of which related portions are *not directly opposite, the existence of finite fragments which as they lie in the structure are identical with their own mirror-image is precluded.*[1]

For if a portion A on one side of such a plane were joined in the same fragment with an enantiomorphically similar portion A′ situated on the other side of the plane, the existence of the translation of A requisite to bring it opposite to A′ would necessitate the existence of a similar translation in the *same direction and similarly related to the structure* of A′, which would therefore bring the latter opposite to a portion identical with A in form but not in position, and this third portion *must therefore, for the sake of symmetry, also form part of the same fragment.*

Consequently, unless an infinite chain of enantiomorphically related portions A, A′, &c. is found in the same fragment, no two such can in the last mentioned case be united *without impairing the symmetry of the structure*;[2] and, failing union of this kind, no fragment identical with its own mirror-image can be formed.

It is possible to state the method by which the classification referred to is to be accomplished in what is perhaps a conciser and plainer way.

In another place I have defined singular point-systems as those whose points consist of fewer points, and these in more symmetrical situations than are occupied by the other point-systems of a homogeneous structure.[3] *The different types of partitioning can be distinguished according to the nature of the central or of some most symmetrically placed point in one of the similar fragments, each different kind of singular point found in any given type of homogeneous structure forming the central or most symmetrically placed point of a distinct type of fragment, and there being in addition to the types thus distinguishable one other type of fragment in each case, that which has no point in it which the nature of the type of structure requires shall be more symmetrically situated than the rest.*[4]

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[1] They may, however, considered apart from the structure, possess the property as a special peculiarity not derived from it. Comp. note 2, p. 131.

[2] Comp. *Zeitschr. für Kryst.* XXV. p. 88.

[3] *Zeitschr. für Kryst.* XXIII. p. 60.

[4] The least symmetrical type of all (hemipinakoidal-anorthic), as it possesses no singular points, presents but one type of partitioning for simple structures, *i.e.* for structures whose ultimate fragments are all similar.

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The problem of finding the different types of partitioning possible resolves itself therefore into the problem of finding the different kinds of singular points present in each type of homogeneous structure.

The solution of the latter, as I have shown in the paper already referred to, depends on ascertaining precisely certain features of each type of structure, viz.:—

1. The different sets[1] of axes of rotation present.
2. The centres of symmetry.
3. The planes of symmetry which have the enantiomorphically related points directly opposite on their two sides.
4. The symmetrically placed planes with accompanying centres, such as those of the two types of structure identical with their own mirror-images, which have no centres of symmetry or planes of symmetry.[2]
5. The points and lines of intersection of these various elements of symmetry.

The table given below shows the result of applying the method of classification described to a few of the types of homogeneous structure belonging to the regular or cubic system; but before passing to this it may be helpful to state some conclusions as to the general features of the similar fragments produced by symmetrical partitioning.

The fact that no translation (Schiebung) or screw movement (Schraubung) can bring a fragment to coincidence with itself, shows that the only coincidence movements (Deckbewegungen) with which we have to deal are *rotations* of the unbroken structure.[3]

No fragment can, it is evident, have more than one axis of rotation *with the same direction;* and if it possesses more than one, inclined one to another, all such axes must intersect in a single point.

If a fragment possesses a digonal axis of rotation and no other, it will contain two identically similar points of every kind found in it, except those lying on the axis.

If a trigonal axis and no other, 3, except those lying on the axis.
tetragonal ,, ,, 4, ,, ,,
hexagonal ,, ,, 6, ,, ,,

[1] See note 3, p. 131.

[2] There are some such planes in other types of structure besides the two 63c and 64c here referred to, which form a group by themselves. Comp. *Zeitschr.* XXIII. 59, XXV. p. 90.

[3] A fragment may, as we have intimated, have an axis or axes not found in the unbroken structure, but this is outside our province here, as we are not making a classification based on individual peculiarities of the fragments, but one based on the general features of the different types.

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If two axes of rotation which are *not* both digonal axes intersect, it is evident that other similar axes must also pass through the point of intersection, the positions of which are discovered by carrying out movements about the two given ones; but the number of identical points involved does not equal the product of the co-efficients of all the intersecting axes. Thus the centre of a "24 punkter" of Sohncke is the point of intersection of six digonal, four trigonal and three tetragonal axes.

For each set[1] of axes of rotation in a homogeneous structure there will be at least one distinct corresponding group or type of varieties of partitioning, whose similar fragments possess such an axis. Also at least one distinct group for each different type of intersection of two or more axes, if there be any intersections, and at least one besides these of cases where the fragments possess no axes.

As regards those cases where the structure is identical with its own mirror-image, a plane of symmetry of a fragment, or any plane through its centre of symmetry, if it have one, will divide the fragment into two similar parts. If the fragment has an axis it also must evidently be central.

In no case can the fragment taken alone possess a plane of symmetry on the opposite sides of which corresponding points are not directly opposite (*i.e.* no Gleitebene), because such a property would, as already explained,[2] require the fragment to be infinite in one direction.

If an axis of a homogeneous structure lies in a plane of symmetry, the halves of the space units lying around the axis have contact with those of the same hand in this line only. It follows that when the fragments of the structure are such that this axis survives in them, they must, in order to be continuous *in substance*, also possess the plane of symmetry.

Summary.

The above investigation shows:—

1. The nature of homogeneity of structure, and the properties which distinguish it from structureless homogeneity. The new definition of a homogeneous structure recently put forward by the author in Groth's *Zeitschrift* is given.

2. A method of realising in a concrete form, and with great generality, the kind of repetition in space which constitutes homogeneity of

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[1] See Note 3, p. 131.

[2] See above, p. 132.

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structure, the models employed for this purpose each consisting of a number of similar plaster hands appropriately arranged in space.

The total number of types of arrangement, all of which can be represented in this way, is 230, this being the number of typical point systems described by Fedorow and Schönflies, derived by their extension of Sohncke's methods. The various types of homogeneous structure, like the corresponding point-systems, all fall into the 32 classes of crystal symmetry.

3. What property common to all homogeneous structures whatever most nearly corresponds to Thomson and Tait's definition of homogeneity.

4. Reasons for regarding as untenable the arguments put forward by Fedorow in support of his recent attempt to select from among the types of homogeneous structure those which are possible for crystals, and to determine the shapes of their ultimate units.

5. The possibility of so classifying all conceivable ways of symmetrically partitioning all the types of homogeneous structure as to avoid all reference to the nature of the cell-faces, whether plane or otherwise, and, in other respects also, be perfectly general. Some reasons for undertaking this classification, notwithstanding its complexity, are given, the chief one being the relation of symmetrical partitioning to some stereo-chemical and other experimental facts.

FRAGMENT OF A TABLE OF THE VARIOUS KINDS OF SYMMETRICAL SINGLE PARTITIONING WHICH CAN BE MADE OF THE TYPES OF HOMOGENEOUS STRUCTURE.

Type partitioned.	No. of Variety.	Elements of Symmetry of the Homogeneous Structure which survive in a Cell or Element of the Partitioning
1	(1)	A trigonal axis
,,	(2)	None
$1a_1$	(1)	A trigonal axis and a centre of symmetry
,,	(2)	A trigonal axis only (the fragments are enantiomorphs)
,,	(3)	None (fragments enantiomorphs)
2	(1)	A trigonal axis
,,	(2)	A digonal axis
,,	(3)	None
$2a_1$	(1)	A trigonal axis and a centre of symmetry
,,	(2)	A trigonal axis only (fragments enantiomorphs)
,,	(3)	A digonal axis ,, ,,
,,	(4)	None ,, ,,
$2b_1$	(1)	A trigonal axis only , ,,
,,	(2)	A digonal axis ,, ,,
,,	(3)	None ,, ,,
3 or 4	(1)	A trigonal axis and a digonal axis
,,	(2)	A trigonal axis only
,,	(3)	A digonal axis only
,,	(4)	None

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FRAGMENT OF A TABLE OF THE VARIOUS KINDS OF SYMMETRICAL SINGLE PARTITIONING WHICH CAN BE MADE OF THE TYPES OF HOMOGENEOUS STRUCTURE—*Continued.*

Type partitioned.	No. of Variety.	Elements of Symmetry of the Homogeneous Structure which survive in a Cell or Element of the Partitioning.
5	(1)	A trigonal axis and a digonal axis
,,	(2)	A trigonal axis only
,,	(3)	A digonal axis only, of the kind which intersects a trigonal in the unbroken structure
,,	(4)	A digonal axis of the other kind
,,	(5)	None
$5a_1$	(1)	A trigonal axis and a centre of symmetry
,,	(2)	A trigonal axis and a digonal axis (fragments enantiomorphs)
,	(3)	A trigonal axis only (fragments enantiomorphs)
	(4)	A digonal axis only, of the kind which intersects a trigonal in the unbroken structure (fragments enantiomorphs)
,,	(5)	A digonal axis of the other kind (fragments enantiomorphs)
,,	(6)	None (fragments enantiomorphs)
6	(1)	Four trigonal and three digonal axes
,,	(2)	A trigonal axis only
,,	(3)	A digonal axis only
,,	(4)	None
$6a_1$	(1)	Four trigonal axes, three digonal axes, and a centre of symmetry, with accompanying three planes of symmetry
,,	(2)	A trigonal axis only (fragments enantiomorphs)
,,	(3)	A digonal axis and a plane of symmetry
,,	(4)	None (fragments enantiomorphs)
$6a_2$	(1)	Four trigonal and three digonal axes (fragments enantiomorphs)
,,	(2)	A trigonal axis and a centre of symmetry
,,	(3)	A trigonal axis only (fragments enantiomorphs)
,,	(4)	A digonal axis only ,, ,,
,,	(5)	None ,, ,,
$6b_1$	(1)	Four trigonal axes, three digonal axes, and six similar planes of symmetry
,,	(2)	A trigonal axis and a plane of symmetry
,,	(3)	A digonal axis only (fragments enantiomorphs)
,,	(4)	None ,, ,,
$6b_2$	(1)	Four trigonal and three digonal axes (fragments enantiomorphs)
,,	(2)	A trigonal axis only (fragments enantiomorphs
,,	(3)	A digonal axis only ,, ,,
,,	(4)	None ,, ,,
		&c. &c.

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On the Humite Series.

By Professor W. J. Lewis, M.A.

[Read April 14th, 1896.]

THE humite series has formed one of the most interesting problems to mineralogists ever since Scacchi established the three types. I may, perhaps, recall that he found the crystals to be divisible into three classes, all capable of representation by reference to a common parametral plane and three zone-axes at right angles to one another. But the three classes differ in the following respects:—(1) Each has a peculiar set of faces, and, with the exception of the pinakoids and the actual or theoretical prisms, few of the forms coincide in different types. (2) Whilst all the faces on crystals of one class can be easily represented by quite simple indices, such as (111) (123) (103) by a judicious selection of one of its faces as parametral plane, the faces on crystals of the remaining two classes give for the same parameters very high and complicated indices. For the sake of simplicity of indices a different parametral plane has therefore to be assumed for each class. (3) Whilst in one class, that now specially denoted as humite, the faces are arranged about the axes so as to conform to the holohedral forms of the rhombic system, in the remaining two classes the faces are developed in sets of four tautozonal planes in the manner characteristic of the oblique system. This latter character so impressed Miller, whose material was limited, that he has described the mineral as oblique. Miller's crystals were undoubtedly of the kind now termed clinohumite. His determination, apparently simultaneous with Scacchi's work, is very accurate, and the commonest twin law of the class is given in a very precise manner.

The next important contribution to our knowledge was vom Rath's classical memoir published in 1871 (*Pogg. Ann. Erg. Bd.* V.). He confirmed Scacchi's results, and gave a very exhaustive description of the twins of the different classes, many of which had hitherto escaped notice. Referring the crystals to the same axes, he gave the following parameters, which have been but slightly modified since,

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	a	b	c = $m\gamma$
Chondrodite ...	1·08028 :	1 :	3·14379 = 5 × ·62876
Humite... ...	1·08028 :	1 :	4·4013 = 7 × ·6288
Clinohumite ...	1·08028 :	1 :	5·65884 = 9 × ·62879

The faces present on crystals of the three varieties are now all capable of simple representation. Thus we have common prisms {110}, {120}, also a series of domes $i_1\{011\}$, $i_2\{012\}$, &c.

The faces of forms $e_1\{101\}$, $e_3\{103\}$, &c., which should form domes, are found in chondrodite and clinohumite to be frequently present in pairs of parallel faces only, or those inclined to one another are differently developed.

Again, we have zones common to all the varieties with forms $n_1\{111\}$, $n_3\{113\}$, &c., and $r_1\{121\}$, $r_3\{123\}$, $r_5\{125\}$, &c., which should constitute pyramids of eight faces. This is the case in humite. But in the other two varieties we have frequently only sets of four tautozonal faces, the characteristic form of the oblique system, and the pyramid, when eight faces with equal indices are present, is generally divisible into two sets of four tautozonal planes, owing to different development.

In 1876 M. DesCloizeaux showed that chondrodite and clinohumite both form polysynthetic twin-lamellæ parallel to (001), and that sections of such crystals parallel to the pinakoid $b(010)$ do not, between crossed nicols, extinguish the light in the lamellæ simultaneously or parallel to the base. In chondrodite the direction of extinction makes an angle with (001) of nearly 30°, and is nearly parallel and perpendicular to the important normal $e_5(105)$. In clinohumite the extinction of the lamellæ occurs in a direction inclined at +11° to the vertical axis. This had already been established by Prof. E. S. Dana for chondrodite from Brewster, and was at a later date confirmed by him for clinohumite. At the same time M. DesCloizeaux showed that humite has no twin lamellæ parallel to (001), and that the extinction in sections parallel to (010) is parallel to the face (001). Hence humite is rhombic, whilst chondrodite and clinohumite have to be relegated to the oblique system. It has not, however, been found possible to find variations in the angles between the base and faces, such as $\pm e_3$ $\pm n_3$, which have like indices but lie on opposite sides of the axis ZZ'. Hence the angle between the axes of X and Z has to be regarded as 90°; and Prof. Dana says that careful examination of chondrodite crystals has convinced him that the angle XOZ cannot differ by 1′ from 90°.

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In 1894 Prof. Penfield showed by a series of careful analyses that if the water be taken as hydroxyl (HO) replacing fluorine, the three varieties have the following composition :—

Chondrodite	...	...	$Mg_3[Mg(F,OH)]_2(SiO_4)_2$
Humite	...	...	$Mg_5[Mg(F,OH)]_2(SiO_4)_3$
Clinohumite	...	...	$Mg_7[Mg(F,OH)]_2(SiO_4)_4$

He also points out that the number of atoms of Mg in each gives exactly the multiple of $\gamma = \cdot 6288$ required for the parameter c. This being the rule he then indicates the possibility of an extension of the series $Mg_{2x-1}[Mg(F,OH)]_2(SiO_4)_x$ with parameters $a : b : (2x+1)\ \gamma$, and also that the lower term is probably $Mg[Mg(F,OH)]_2SiO_4$ with parameters

$$1 \cdot 08028 : 1 : 1 \cdot 88628.$$

In passing from one member to the next one in the above series the chemical change consists in the addition of a molcule of forsterite Mg_2SiO_4 or olivine $(Mg,Fe)_2SiO_4$, and the addition of 2γ to the parameter c.

Now Prof. Sjögren[1] (*Bulletin of the Geol. Inst. of Upsala* II.) has recently announced the discovery of prolectite with the parameters just given, *i.e.* with $c = 3\gamma$. The amount of material at his disposal has not enabled him to analyse the substance; but there is a strong presumption that its composition will accord with that suggested by the rule of the series.

Now the comparison with olivine, though frequently made, has not brought out the relation between it and the members of the above series with much precision. This is to some extent due to the recent adoption of the parameters of Kokscharow instead of those of Naumann and Miller. If we take the representation given in Miller's edition of *Phillips' Mineralogy*, 1852, we have parameters

$$a : b : c = 1 \cdot 0733 : 1 : 2 \times \cdot 6297,$$

where a and b are almost identically those of the humite series, and the multiple of γ (namely 2) is the number of atoms of Mg. The parameters of forsterite differ very slightly from those of olivine.

To carry the inquiry to the lowest possible step, we must go to enstatite and hypersthene $(Mg,Fe)SiO_3$. Unfortunately the crystals of these substances so far available leave much to be desired. The divergence from the parameters $a : b : \gamma$ is much greater than those which exist in the preceding minerals. The prisms {110}, {120} have angles differing greatly from those in the same forms of olivine and the humites, and the acute angle of {110} occupies the position of the obtuse one in the humites. But if we consider the zone [100,001] —a pseudo-hexagonal

[1] See p. 161 below.

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zone in all the minerals—we find the ratio of $a : \gamma = 1{\cdot}0685 : {\cdot}62886$; a very close approximation to that required by the series. The divergence from the rule of the series is then thrown on the parameter b, which becomes 1·1013, when c is ·62886. The variation in the ratio $a : b$ is not surprising, seeing that there has been a change from an ortho- to a metasilicate.

We may call attention to the remarkable fact that the twin-face in all the minerals, except clinohumite, is practically the same face, *i.e.* one making an angle of nearly 30° with $c(001)$, which meets the axes at distances a and γ, and has the indices (101), (102), (105), (107), in the different minerals.

In clinohumite the common law is twin-face $-e_3$ $(\bar{1}03)$, *i.e.* a face at nearly 90° to (109).

The examination of prolectite is as yet too incomplete, owing to lack of material, for us to know whether it will correspond to or deviate from the common rules of twinning.

Again, as to habit, we have the curious fact that all the minerals have a marked inequality in the development of like faces, so as frequently to give the appearance of oblique crystals. The extinctions and the other optic phenomena have been very carefully determined by several observers of the greatest skill. We can, therefore, hardly expect that future investigations will relegate the whole series to the oblique system. At the same time such a result would harmonise with the close relation which exists between enstatite and pyroxene.

Another common feature is the great predominance of the forms lying in the zones [010], $[1\bar{1}0]$ $[2\bar{1}0]$ *i.e.* faces such as $e(101)$, $e_3(103)$ $n_1(111)$, $n_3(113)$, $r_3(123)$ $r_1(121)$, &c. In these zones the faces are never the same, for being represented by the same indices, they occupy different positions owing to c being a different multiple of γ. It may not be amiss to point out that the minerals closely approximate in density, hardness and fusibility. If V represents the molecular volume, M the weight of the atoms in the chemical molecule, and d the density, and hence $V = \frac{M}{d}$. Then we have—

For Olivine	$V_2 = 44$	$= 2 \times 22$
Chondrodite ...	$V_5 = 105{\cdot}6$	$= 5 \times 21{\cdot}1$
Humite	$V_7 = 150$	$= 7 \times 21{\cdot}4$
Clinohumite ...	$V_9 = 182{\cdot}1$	$= 9 \times 20{\cdot}2$
Enstatite ...	$V_1 = 32{\cdot}8$	$= \frac{8}{2} \times 21{\cdot}9$

The attempt to get topical axes, as suggested by Herr Muthmann, clearly gives no new relation.

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Notes on a biotite-cyanite-cordierite-rock from the Upper Satlej Valley, N.W. Himalayas.

By Lieut.-General C. A. McMahon, V.P.G.S.

[Read June 23rd, 1896.]

SOME years ago I found in the bed of the Satlej at Wangtu, in the N.W. Himalayas, about 80 miles, as the crow flies, north-east of Simla, a boulder of the rock described in the following pages. It is composed of biotite, cyanite and cordierite, with apatite and rutile as accessory minerals.

The specimen has a specific gravity of 2·92. Its structure is holocrystalline, and its minerals show no trace of parallelism in their orientation. It is, I think, a product of contact metamorphism.

I have not come across the above rock *in situ*, but the Upper Satlej at and above Wangtu is a region of intense granitic eruption and cyanite and other contact-metamorphic minerals, are to be found there in great abundance.[1]

Thin slices having been studied under the microscope, the following remarks are offered on the rock and its component minerals.

Biotite.

The biotite is quite black when viewed macroscopically, but in thin slices and in transmitted light it exhibits strong pleochroism, (c) being dark green, (b) green, and (a) greenish yellow. The scheme of absorption is $a > b > c$.

The whole of the colouring matter and the bases are removed from the biotite on heating in nitric acid, and the solution thus obtained reacts for iron, magnesia and lime. The residue consists of amorphous silica which is completely soluble in a solution of caustic potash. The interesting point is that this amorphous silica, after yielding its bases to hot nitric acid, preserves the cohesion, the hexagonal shape, and the pronounced lamination of biotite. Whilst completely retaining the

[1] Some fine specimens of cyanite found in granitoid gneiss a mile or two above Wangtu were exhibited when the paper was read.

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characteristic form and lamination of biotite, however, it loses the whole of the optical properties of that mineral and acquires those of amorphous silica. After treatment with acid it has no action on polarised light, and its refraction falls from that proper to biotite, to that proper to amorphous silica. The indices of refraction for biotite are n_g 1·606, n_p 1·562; but I find from actual observation that the refractive index of the siliceous residue of the biotite is higher than 1·374, and lower than 1·437; the mean of these figures being 1·405.

The above facts are, I think, suggestive. They not only show that the optical properties of biotite depend on the bases present—a conclusion arrived at by other observers in the case of some other minerals—but they also appear to throw some light on the constitution of the biotite molecule, and suggest that the bases are linked to the silica in such a way that their atoms may be replaced by water, or its constituents, without the molecule being broken up. That the loss of the bases did not break down the molecule, seems to me clear from the fact that though the optical and other physical properties of biotite were changed, the hydrated siliceous residue retained the form of biotite as perfectly as ever. Had the biotite molecule been broken up, we should have got pulverulent or flocculent silica, but the form of biotite would, it seems to me, have been lost.

Biotite is now so fully recognised as a product of contact metamorphism that no remarks on this subject seem necessary. I would only say, in passing, that I have seen several interesting cases in the Satlej Valley of the production of biotite by the contact action of granite on basic rocks of igneous origin. I place on the table a hand specimen in illustration of this statement. One half of the specimen consists of brown biotite, and the other half of a fine-grained diorite or epidiorite.

Cyanite.

The cyanite seen in the Wangtu rock is white in reflected, and colourless in transmitted light. It is in blade-like prisms with irregular terminations and somewhat corroded sides. The longitudinal and transverse cleavages are usually well developed. Sometimes the former become very pronounced and the mineral passes into sillimanite. Sometimes the cyanite frays out into sillimanite needles, or needles of this mineral are seen in its immediate vicinity; the passage of the one mineral into the other is never, however, absolutely complete, for though it loses its oblique and puts on straight extinction, the major axis remains at right angles to the length of the prism instead of becoming parallel to it, which is the normal position for sillimanite.

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Cyanite is, as is now well known, a recognised product of contact metamorphism arising from the vicinity of granite, and its abundance in the zone of contact-metamorphism in the south-eastern Highlands of Scotland, has been described by Mr. G. Barrow in his able paper published in the forty-ninth volume of the *Quarterly Journal of the Geological Society* (p. 330).

Cordierite.

Cordierite in this rock was the last mineral to crystallise. It is uniformly allotriomorphic and it does not present any suggestion of crystallographic form or of cleavage. Its refractive index I found to be above 1·538 and below 1·547, which would do for quartz, andesine, oligoclase or cordierite. Its double refraction did not serve to distinguish it, and in specific gravity the above minerals come near each other. Its behaviour in converging polarised light showed that it was not quartz. All doubt, however, as to the identification of the mineral in the Wangtu rock has been removed by Mr. G. T. Prior, F.G.S., Mineralogical Department of the British Museum, to whom I am much indebted for the determination of this mineral. He succeeded in isolating and analysing minute fragments, which yielded magnesia and the other constituents of cordierite, and exhibited a delicate but appreciable dichroism under the microscope.

Accessory Minerals.

The specimen contains apatite, mostly in granules, though nests of micro-prisms occur here and there. The granules are soluble in nitric acid, and the solution reacts for phosphoric acid with ammonium molybdate, and for lime with sulphuric acid. The optical properties of the granules are those of apatite.

Numerous small crystals of rutile are also to be found in very thin slices. They occur most frequently in the biotite; less so in the cordierite, and more rarely in the cyanite. They are sausage-shaped, or in stumpy crystals with rounded angles. I have only observed one or two cases in which the rutile assumes the needle shape. Most of the crystals of rutile polarise brilliantly.

No magnetite is to be seen, but now and then there is a little ferric oxide stain.

General Remarks.

One of the questions which arise in connection with this rock is its probable origin. What kind of rock was it before it was metamorphosed?

A cyanite-gneiss has been described by Mr. Barrow, in his interesting

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paper before referred to, the crystalline structure of which the author attributes to the contact action of granite, intensified by the great depth below the surface at which that action took place. "The sedimentary origin," the author writes, "of the group of rocks last described" [those of the staurolite zone] "will probably be admitted without question, but in the case of the more highly altered rocks" [this apparently includes the cyanite zone] "it is not so clear." The author appears, however, to incline to the view[1] that the rocks of the sillimanite and cyanite zones are also of sedimentary origin.

There are some points of resemblance and some points of difference between Mr. Barrow's cyanite-bearing gneisses and the rock above described. The former are foliated but the latter possesses a perfect granitic structure. The Scotch rocks contain muscovite, felspar, free quartz, garnet, chlorite, iron ores and tourmaline, none of which are present in the Wangtu rock, whilst the latter contains cordierite, apatite and rutile, absent from the Scotch rocks. Biotite and cyanite are common to and abundant in both.

The high specific gravity of the Wangtu rocks, coupled with the absence of free silica, and the presence of apatite, are points which seem to bear on the question of origin. Apatite is characteristic of some rocks of igneous origin, and free silica is a characteristic constituent of aqueous sediments.

I framed an estimate by taking the minerals contained in the Wangtu specimen in such proportions as would give a rock with a sp. gr. of 2·92, and calculated the chemical contents from the formulæ of these minerals. The result came near the composition of augitite. Until the Wangtu rock is found *in situ*, however, nothing definite can be affirmed regarding it, but I think the probabilities of the case are in favour of its being a contact-metamorphic rock of original igneous origin.

Mr. Barrow, in the paper already referred to, called attention to the fact recorded by Dana in the last edition of the *System of Mineralogy*, that cyanite is, at a temperature of 1320°-1380° C., converted into sillimanite. I have shown that the commencement of this change had been set up in the Wangtu rock. We may, therefore assume that the latter was heated until it reached a temperature of about 1320° C. If so, the heat to which the rock was raised was sufficiently high to have completely fused a basic rock of igneous origin. The melting point of diabase is said[2] to be between 1100° C. and 1170° C., and that of ordinary

[1] *l. c.* p. 351.

[2] Lord Kelvin quoting Carl Barus, *Nature*, Vol. LI. p. 439.

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basalt 815° C.[1] The minerals of which the Wangtu rock is composed therefore, probably resulted from the fusion of the original rock from which it was derived, and from the rearrangement of its component silica and bases.

Looking at the rock from this point of view, its microscopical examination presents some points of interest. The first stage in the formation of the metamorphosed rock seems to have been the crystallising out of the contact minerals, and subsequently when the heat reached its maximum the last formed and more acid mineral, cordierite, began to corrode, and eat into the more basic minerals.

This corrosion and partial re-solution may be traced in the illustration (Plate III. Figs. 1-5). The action of the cordierite on the biotite is rather remarkable, the majority of the biotite crystals being fringed with tags of half dissolved mica. A question naturally arises whether these tags are portions of the biotite in process of re-solution, or whether they represent a re-deposition of mineral matter previously held in solution in the cordierite. I do not think the latter is the true explanation for the newly deposited mineral—especially if it were biotite, deposited on biotite—would surely have been deposited in a layer on the previously formed mineral and not in the form of a fringe of tags depending from the edges of the biotite leaves. Moreover the faces of these leaves often exhibit a series of vermicular marks resembling microscopic worm burrows, which seem to be due to the corrosive action of the comparatively acid mineral on the basic biotite suspended in it.

These tags have a high refractive index, the major axis is at right angles to their length, many of them are distinctly dichroic, and biotite is the only mineral they are attached to.

The study of this, and other crystalline rocks, has led me to the conclusion that a double action may be set up in such rocks when subjected to thermal action under pressure, and more or less completely fused. There is first a constructive action in the crystallising out of minerals, and this may in some cases be succeeded by a destructive action in the corrosion, and partial re-solution, of some or all of these minerals, by the comparatively acid mineral that plays the rôle of the base or residuum. A change of temperature, or an alteration in the melting point due to relief of pressure, seems sufficient in some cases to bring this about. This double action is often to be seen in granites.

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[1] Professor Sollas relying on Dr. Joly, *Nature*, Vol. LI. p. 534.

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NOTES AND COMMENTS.

THE Society has lost one of its Corresponding Members in the person of Professor G. A. Daubrée, the Director of the École des Mines, who died on the 20th of May, 1896, at the age of 82. Among his numerous publications on experimental geology and the allied subjects were many of extreme importance to the Mineralogist, especially in relation to the origin of minerals. In fact, the desire to explore the suggestive problems of mineral genesis seems to have inspired not only those remarkable investigations which are included in his *Etudes synthétiques de Geologie Experimentale* and in his well-known treatise on Underground Waters, but also his lively interest in Meteorites. The death of this eminent man is as great a loss to Mineralogy as to Geology.

We have also to record the following deaths which have taken place since the last issue of this Magazine :—On September 22nd, 1895, died Dr. Friedrich Nies, an ardent Mineralogist, who was Secretary of the Geological Association of the Upper Rhineland; and on October 10th, 1895, in his 49th year, Dr. Albert E. Foote, the well-known mineral collector and dealer, of Philadelphia, through whose enterprise and energy many new and important minerals were secured for the Museums of the United States and of Europe.

Among recent appointments are to be mentioned that of Dr. O. Mügge, of Münster, to the Professorship of Geology at Königsberg, of Dr. Karl Busz to the Chair at Münster vacated by him, and of Mr. H. A. Miers to the Professorship of Mineralogy at Oxford, in succession to Professor N. Story-Maskelyne, retired.

The following is the subject offered for competition by the Fürstl. Jablonowskische Gesellschaft, in Leipzig, for a prize of £50, to be awarded in 1899 :—

An experimental investigation upon the problem as to what are the

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conditions which determine the development of the various simple forms, or their mutual combinations, in crystals; regard being also had to the literature which bears upon the subject. It is desired that the investigation shall take into account such subtances as would yield results which might be extended to natural minerals.

The Memoir is to be written anonymously in German, Latin, or French, enclosed in a sealed cover with motto, and must be sent before the 30th of November, 1899, to the Secretary of the Society.

OBITUARY.

Alexander Henry Green, F.R.S.

THE Mineralogical Society has lost a prominent Member by the death of Professor Green on the 19th of August, 1896. He was born in 1832; having graduated as 5th Wrangler at Cambridge in 1855, he was in 1861 appointed an Assistant Geologist on the Geological Survey; in 1875 he was appointed Professor of Geology at the Yorkshire College of Science at Leeds, and was largely instrumental in achieving the success of that institution in its early days.

In 1888 he was elected to the Chair of Geology at Oxford. Though a Geologist by profession, he always took an active interest in Mineralogy; he was almost an original member of this Society, and was a member of Council on various occasions, beginning with the year 1879. He was gifted with a singularly clear and effective style which invested his words, whether spoken or written, with a great charm; of this his book on Physical Geology is a conspicuous example.

This power of lucid exposition rendered him a most attractive teacher, while his hearty and genial character endeared him to all those who enjoyed his friendship.

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REVIEWS.

An Introduction to the Study of Rocks. By L. Fletcher, Mineral Department, British Museum (Natural History). There are many ways in which a collection of rocks can be arranged, each carrying its own useful lesson. The chief types of rocks may be selected and so placed as to indicate their mutual relations as constituents of the earth's crust; or they may be made to illustrate the various ages of the rocks, and the progressive changes that the earth went through during its growth; or again the different products of each locality may be placed in close proximity so as to illustrate the mineral resources, age and character of the rocks at each locality; or again, the collection may embrace the chief sorts of rocks and endeavour to give the history of each important class. But the chief interest of rocks to the mineralogist is as the habitat of minerals, and we suppose that this is the purpose which Mr. Fletcher had in view in writing this guide and in arranging the collection to which it refers.

But even with this comparatively limited object in view, the mineralogist no less than the petrologist finds his task a very difficult one, for no one character can be taken alone, and almost every set of characters when taken as a basis leads to one or more absurdities. Rocks are mineral aggregates and can be broken up mechanically into one or more mineral species, usually in combination with more or less matter which, though really complex, cannot be thus physically resolved; minerals and amorphous matter can be formed in several different ways so that rocks may have many different kinds of origin. On going to the rock-mass itself, it is found to be a complex entity; the simple "petrical individual" is very rarely to be met with, and it becomes necessary to confine attention to small portions of the rock at a time, and to name these if necessary, although in doing so it is well to notice their relations to the rest of the rock-mass both in structure and composition. The list and explanation given in this introduction of the chief "lithical" characters to be looked for will be found to be a most useful and exhaustive one. The "petrical" or larger features have also been treated with adequate justice. Aided by the knowledge thus acquired we are now prepared to enter upon a classification, remembering always that "the knowledge of a fragment is

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merely an aid to the knowledge of the whole," for "a single mass may consist of more than one kind of rock," although such are, as a rule, merely varieties of the main type. Although the age of the rock may be an important character in indicating a particular phase in the earth's history, its chief function is in producing alterations in the rock, often of such import that two rocks initially identical may become totally unlike each other, or rocks originally quite different may eventually result in the same, *e.g.* the serpentines.

In endeavouring to hit upon the best basis for a classification it is found that mode of origin is the most reliable guide to the mineralogist, as well as to the geologist and petrographer; with the aid of it we are able at once to divide the sediments or aggregate rocks from the igneous group, and although when we carry this method to its logical issue we are often compelled to place in widely separated divisions one or two rocks which to ordinary methods of research are identical, this is better than such grouping as that of crystalline schists, which includes igneous rocks with flow-structure, dynamically metamorphosed rocks, products of contact-metamorphism, and possibly others to which all or several of these methods have contributed.

The classification to be adopted chooses the following chief types round which others may be grouped; the grouping of the igneous rocks will be found to be in the main a chemical one, and not widely different from that generally in use amongst geologists:—granite, syenite (including felspathoid rocks), diorite, gabbro (also including felspathoid rocks), and dunite. As subdivisions of these types are treated porphyritic, "mero-crystalline" (including semi-crystalline and crypto-crystalline varieties), and glassy types; and these forms are again divided by their minuter mineralogical variations. Then we have the gneisses and crystalline schists, the tuffs, sandstones and clays, the limestones and marls, and finally the coals.

The work will be found very useful to the student of classification, as he will find many of the old facts put strongly and often in quite a new light. Many of the chief difficulties are gone into very thoroughly, while the whole book is a conscientious attempt to make very clear to the mineralogist the nature and characters of the habitats of those minerals of which the bulk of the earth's crust is built up. W. W. W.

C. F. Rammelsberg; *Handbuch der Mineralchemie.* Zweites Ergänzungsheft. Leipzig, 1895.

In this supplementary volume to the second edition of his invaluable

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Handbook, the venerable Professor displays once more his marvellous industry, and brings together a critical summary of all the mineral analyses which have been published since the year 1886. As in the earlier volumes, the author confines himself to empirical formulæ, and dismisses, as too speculative for his handbook, the numerous recent attempts to establish structural formulæ for minerals. On the other hand, he adopts, for example in the arsenides, oxides, &c., such rational formulæ as seem to him most in accordance with the facts. With such compounds as the oxy-chlorides, the chlorine is not regarded as capable of replacing the oxygen, and similarly the radicle RCl or RCl_2 is assumed in the borates, carbonates, sulphates, phosphates and silicates.

In these matters the author confesses himself strongly conservative, and he entirely refuses to accept the newer views regarding the replacement of fluorine by hydroxyl in many so-called hydrated compounds.

Thus, in the case of topaz, he adheres to the formula $mAl_2SiO + nAl_2SiFl_{10}$, and regards the water as indicating incipient decomposition.

Like the previous volumes, the book is one which is an absolutely indispensable work of reference to every Mineralogist.

Ostwald's Klassiker der exakten Wissenschaften, No. 75. *Abhandlung über die Herleitung aller Krystallographischen Systeme mit ihren Unterabtheilungen aus einem einzigen Prinzipe, von Axel Gadolin, deutsch herausgegeben von* P. Groth.

This excellent series of annotated German translations of classical papers in the various sciences, is now enriched by Professor Groth's edition of Gadolin's masterpiece. In this highly original memoir the author, without knowledge of the previous investigations of Hessel and of Bravais, proved in the year 1867, by an extremely simple and elegant method, that if the law of rational indices be accepted, then only 32 classes of crystals are possible, distinguished from each other by their characteristic symmetry.

At the present time when these conclusions are generally based upon structural theories, it is very suitable that the proof which is independent of any speculations regarding structure should be recalled to the minds of students of this subject.

Professor Groth's brief notes and the historical sketch by which they are preceded are excellently adapted to make the subject intelligible; particular attention may be drawn to the note on Chap. III., where an explanation is given of the modern conception of "composite" or "alternating" symmetry.

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Abstracts.

Geology of the Highwood Mountains of Montana (W. H. Weed and L. V. Pirsson, *Bull. Geol. Soc. Amer.* VI, pp. 389-122). The mountains of which an account is given in this paper form one of the detached groups to the east of the Rocky Mountain Cordilleras. They consist of the denuded remains of a group of volcanoes which were erupted through cretaceous strata.

A characteristic feature of the geologic structure is the enormous number of dykes which radiate outwards from a number of volcanic cores surrounded by tuffs and lava-flows.

The sedimentary strata consist of sandstone and clayey shales. In the lowest series, classed II as Kootanie, occurs the most important single coal seam in the state of Montana.

Most of the volcanic cores consist of granular rocks (syenite and a new type called shonkinite), showing that considerable denudation has taken place.

The chief interest of the paper centres in the description of the remarkable structure of the igneous mass known as Square Butte, which, although genetically and geologically part of the Highwoods, is geographically a distinct and separate elevation. Square Butte presents the appearance of a short but huge cylindrical mass of white rock resting upon a low broad truncated cone of dark rock. The result of the authors' observation seems to show that it is a laccolite which has been intruded in cretaceous sandstones. When intruded the mass was homogeneous, but while it was still in the liquid state a process of differentiation set in, the result of which was that the magnesia, lime and oxide of iron were concentrated in an outer zone to form on solidification a basic granular rock composed essentially of augite and orthoclase (shonkinite), while an inner nucleus richer in alumina, alkalies and silica was left to solidify as a sodalite-syenite.

A remarkable feature of the lower slopes of the mountain formed of the dark basic rock to which the authors give the name shonkinite, is the vast series of "hoodoos" or forest of monoliths into which this rock has been carved by erosion.

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Both the syenite and the shonkinite exhibit a peculiar platy structure, which the authors consider to have been developed during the cooling of the mass, parallel to the form of the laccolitic cover which has been long since removed by denudation.

As regards the petrography of the two rocks, the shonkinite consists mainly of augite (about half the rock consists of this mineral) and orthoclase, but contains also the following accessory minerals: olivine, biotite, apatite, iron ore, albite, anorthoclase, sodalite, nepheline(?), cancrinite(?), and zeolites. The minerals lie unorientated, forming a holocrystalline, coarse-grained hypidiomorphic structure. In chemical composition it is closely related to certain Vogesites and minettes. It bears such a relation to augite-syenite as vogesite to hornblende-syenite.

Analysis of Shonkinite.

SiO_2	...	46·73
TiO_2	...	·78
Al_2O_3	...	10·05
Fe_2O_3	...	3·53
FeO	...	8·20
MnO	...	·28
MgO	..	9·68
CaO	...	13·22
Na_2O	...	1·81
K_2O	...	3·76
H_2O	...	1·24
P_2O_5	...	1·51
Cl	...	·18
		100·97
O = Cl	...	·04
		100·93

The light-coloured inner core of sodalite-syenite has previously been described by Lindgren and Melville (*Am. Jour. Sci.*, XIV, (1893), p. 386). It consists mainly of orthoclase, through which are scattered slender black hornblende (near arfvedsonite) prisms, and small grains of sodalite. The structure is rather coarsely granular, like the shonkinite. Accessory minerals are apatite, albite and analcite, nepheline and natrolite.

G. T. P.

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A new basic orthoclase-bearing rock from Canada. To the increasing number of basic rocks rich in alkalies, and in alkali-felspars, Lawson has recently added new types of somewhat peculiar chemical and mineralogical composition (*Bull. No.* 12, *Dep. Geol. Univ. of Calif.* 1896). They are plutonic rocks forming a laccolitic intrusion some six miles in length among mica-schists of pre-Cambrian (Coutchiching) age at Poohbah Lake in the Province of Ontario. The author gives to these rocks the name malignite, and regards them as constituting a new rock-family. Three types are described. The first is nepheline-pyroxene-malignite, and consists of pyroxene, orthoclase, nepheline, apatite, biotite and sphene, in order of abundance. The pyroxene, making up nearly half the rock, is an ægirine-augite with green and yellow pleochroism and an extinction-angle $c\gamma = 59°$. The orthoclase, which is practically a pure potash-felspar, has been the latest product of crystallisation, and builds large crystal-plates enclosing the other minerals. The nepheline, partly altered by decomposition, occurs in idiomorphic crystals about $\frac{1}{2}$ mm. in diameter, or sometimes forms a micrographic intergrowth with the orthoclase, as in the borolanite described by Teall. The apatite makes up nearly 6 per cent. of the rock, occurring in stout prisms up to 3 mm. long. The chemical composition of the rock is shown in Column I., the most striking feature being the richness in alkalies and lime of so basic a rock. The silica is too low and the lime too high for a nepheline-syenite. The iron and magnesia are lower and the alkalies higher than in the shonkinites of Montana. The alumina is much lower and the magnesia and lime higher than in borolanite. The malignite resembles, however, pretty closely the Vesuvian lavas, and may be regarded as their plutonic equivalent.

	I.	II.	III.	IV.
SiO_2	47·85	51·88	48·86	51·38
TiO_2	—	0·33	—	0·12
Al_2O_3	13·24	14·13	17·40	15·88
Fe_2O_3	2·74	6·45	7·67	1·48
FeO	2·65	0·94	0·48	4·37
MgO	5·68	3.44	—	4·43
CaO	14·36	10·81	—	8·62
Na_2O	3·72	6·72	8·13	7·57
K_2O	5·25	4·57	2·81	4·20
H_2O	2·74	0·18	—	0·42
P_2O_5	2·42	0·96	—	0·98
	100·65	100·41		99·45
Sp. gr.	2·879	2·88	2·93	

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The other two types do not contain nepheline. One is a garnet-pyroxene-malignite, differing structurally as well as mineralogically from the preceding. The orthoclase occurs in large tabular crystals 4 to 6 cm. in length, and has a microperthitic intergrowth of albite. The other minerals, forming a granular aggregate, are, in order of abundance, ægirine-augite, melanite-garnet, biotite, sphene and apatite. In chemical composition (II.) this rock has some resemblance to Brögger's laurvikite, but is poorer in silica and alumina and richer in ferric oxide and lime. A somewhat more basic variety of the rock differs in appearance owing to the felspars being much smaller in size. A partial analysis of this gave the result in Column III.

The third type is amphibole-malignite. This has also large crystals of microperthite, though not so large as before. Garnet is wanting, and the ægirine-augite is mostly replaced by an arfvedsonite-like hornblende, with parallel intergrowths of the two minerals. Biotite, sphene and apatite occur as before. This rock gave the analysis cited under IV. A. H.

A Picrite from Devonshire. K. Busz describes six eruptive rocks from the borders of Dartmoor. Most of these are diabases, but the most interesting is a picrite ("palæopicrite"), from Highweek near Newton Bushel (*Neues Jahrb. f. Min.* 1896, Vol. I. p. 57). The olivine, which is the dominant constituent, is in great part fresh, but shows the serpentine-change in various stages. Chlorite has also been produced near the contact of the olivine with biotite or felspar. Augite occurs usually in imperfect crystals of brownish violet colour in slices, with very feeble pleochroism.

SiO_2	...	...	40·12
Al_2O_3	...	...	7·76
Fe_2O_3	...	...	7·35
FeO	...	...	8·66
CaO	...	...	6·53
MgO	...	...	23·69
Na_2O	...	...	1·20
K_2O	...	...	0·53
H_2O	...	...	4·03
TiO_2	...	...	0·37
P_2O_5	...	...	0·18
FeS_2	...	...	0·20
Cl, CO_2, Cu		...	traces
			100·62

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Enstatite and little flakes of biotite are also present, and a considerable amount of anorthite. Apatite needles are associated with the biotite, and magnetite is found chiefly as a secondary product with the serpentine. The rock has a specific gravity 2·988, and a composition given by the above figures. A. H.

The Triassic eruptive rocks of the Southern Tirol. We have already noticed (p. 114 of this volume) the first part of W. C. Brögger's *Eruptivgesteine des Kristianiagebietes.* The second instalment, since published, deals with the rocks of the long famous district of Predazzo and Monzoni, this digression being justified by the instructive parallel drawn between the Tirolese and the Norwegian rocks (*Vid. Selsk. Skrifter, Math.-Natur. Kl.* 1895, No. 7). After a historical survey of the subject, the author discusses from a chemical and mineralogical standpoint the well-known monzonites, insisting especially upon their classificatory position between the syenites and the diorites, as rocks in which both an alkali- and a lime-soda-felspar are essential constituents. He shows how, from this point of view, a number of rocks from various districts may be referred to the definite passage-group thus established.

The relation between the monzonites of Predazzo and Monzoni and the associated "pyroxenites," of more basic composition, is next considered. Dölter twenty years ago suggested the hypothesis that the two sets of rocks, so intimately bound up together, might have originated from one and the same magma, and Brögger shows how, in the light of modern theories of differentiation, this suggestion acquires great force. In his opinion the pyroxenites occur as marginal facies of the monzonites; and the resemblances and differences between the two are such as are found in other districts between rocks holding a like relationship. In some places there is a gradual transition from monzonite to pyroxenite; elsewhere the boundary is a sharp one. Besides the more usual pyroxenic rocks, there are specially basic varieties, including one which contains magnetite to the extent of one-fifth of its mass.

Brögger next considers the evidence as to the order of succession in time of the various Triassic igneous rocks of the district, a point upon which very different opinions have been held. His conclusions are briefly summarised thus:

(i.) The earliest eruptions are represented by basic dyke-rocks and lavas (melaphyres, augite-porphyrites, plagioclase-porphyrites, amygdaloids, tuffs, etc.)

(ii.) To the later eruptions of the basic dyke-rocks and lavas correspond

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also basic plutonic rocks, of which, however, only a small part (pyroxenites) are preserved as marginal facies of somewhat more acid rocks.

(iii.) These more acid rocks (monzonites) are of intermediate composition, and belong to a distinct group, that of orthoclase-plagioclase-rocks. Their composition is represented in lava-form by certain plagioclase-porphyrites on the Mulatto, etc.

(iv.) Younger than the monzonites and the rocks corresponding to them are red biotite-granites (with a marginal facies of tourmaline-granite) near Predazzo. With these should perhaps be included, not only small veins of aplite, etc., at the immediate boundary of the granite, but also dykes of quartz-porphyry at a greater distance, which were formerly placed with the so-called liebenerite-porphyries.

(v.) The latest eruptions are represented by an assemblage of dykes of small size; partly of ultrabasic composition and rich in iron (camptonites, etc.), partly of intermediate composition and poor in iron (liebenerite-porphyries, here styled nepheline-bostonite-porphyries).

The author next discusses the question of the mechanics of plutonic masses, and especially the probable form of the partly concealed bodies of granite and other deep-seated igneous rocks in general. He criticises adversely the theories of Kjerulf and Michel Lévy, according to which such masses are supposed to extend downward to indefinite depths, and to have assimilated or incorporated large tracts of the strata which they displace; and he argues that the general form of large intrusions must be comparable with that of laccolites. His illustrations are drawn mainly from the Christiania district, and his conclusions on this point are summarised thus:—The plutonic rocks of the Christiania district have been brought into their present position by purely mechanical processes, having been squeezed up and intruded laterally in consequence of a great sinking in of the neighbouring parts of the earth's crust: their composition is not essentially influenced by assimilation of the bounding rocks or melting in of the cover, but is the final result of the processes of differentiation in the original magma of the common magma-basin from which they all originate. Their typical form, apart from their frequent lateral termination along vertical fault-planes, is the cake-form of the laccolite. This conclusion is extended to the Tirol and to other regions which have not been affected by regional metamorphism.

A comparison follows between the chronological succession of eruptive rocks in the Southern Tirol and in the Christiania district. For this purpose Brögger includes with the Monzoni and Predazzo rocks the tonalitic masses of Re di Castello, Monte Aviolo, and Adamello, the

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granite of Brixen, the tonalite of the Riesenferner, and other rocks which there is reason to believe are of Triassic age and belong to the same eruptive region. The progress of differentiation and the mechanism of eruption seem to have followed similar lines in the two districts, although the original magma of the Tirolese basin must have been considerably poorer in alkalies, richer in lime, and different in other respects from that of Christiania.

The last chapter deals with the rather scanty data as to the sequence of eruption of plutonic rocks in other districts. The conclusion reached is that the order "basic, less basic, acid" seems in fact to be so often repeated among the plutonic rocks, that we must regard it as the normal one: the sudden reversion to basic again is found in many cases, but appears to be as often absent. A. H.

Lawsonite, a new mineral (F. L. Ransome, *Bull. Dept. Geol. Univ. California*, I, 301-312, 1895). Lawsonite occurs as a rock-forming mineral in a crystalline schist at the Tiburon Peninsula, Marion Co., California, as large tabular crystals embedded in margarite veins, and as crystals of octahedral or prismatic habit lining and filling cavities. The crystals are orthorhombic, with the forms $c(001)$, $b(010)$, $m(110)$, $d(011)$ and $d'(041)$; the octahedral crystals have m and d equally developed, and the tabular crystals (tabular parallel to c) are often much elongated parallel to one of the edges $c : m$; the faces are deeply striated; twinning on $m(110)$ is common; $a : b : c = 0{\cdot}6652 : 1 : 0{\cdot}7885$; $mm' = 67°16'$, $dd' = 72°53\frac{1}{2}'$. Cleavage b (010) perfect, c (001) less perfect, m (110) indistinct. The small crystals when fresh are clear and colourless, but the larger are of a grey-blue colour of unequal distribution in zones and bands, much resembling cyanite. The plane of the optic axes is $b(010)$, the acute bisectrix being perpendicular to $c(001)$, optically positive; for sodium light, $2V = 84°6'$, $\alpha = 1{\cdot}6650$, $\beta = 1{\cdot}6690$, $\gamma = 1{\cdot}6840$. Strongly pleochroic in the coloured portions, the colour varying from blue to colourless or faint yellow. Hardness about 8; brittle; sp. gr. 3·084 (in powder 3·091). Easily fusible. The mineral is only slightly acted upon by boiling in strong hydrochloric acid, but is completely decomposed by hydrochloric acid in a sealed tube at 140°. Analysis gave

SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	H_2O	Total.
38·10	28·88	0·85	18·26	0·23	0·65	11·42	98·39

At 225° there is a loss of only 0·1 per cent. Formula, $H_4\,Ca\,Al_2\,Si_2\,O_{10}$, or as a basic metasilicate $2Al(OH)_2.Ca(SiO_3)_2$; this is similar to

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carpholite, $H_4 Mn Al_2 Si_2 O_{10}$ (monosymmetric ?), with which lawsonite is probably isomorphous, the prism angles of the two minerals being nearly equal. The associated minerals of the schist are margarite, epidote, actinolite, glaucophane and red garnet, these varying considerably in distribution, so that the colour of the rock is green, blue, yellowish-green, or red. L. J. S.

Optical Properties of Lithiophilite and Triphylite. (S. L. Penfield and J. H. Pratt, *Amer. Journ. Sci.*, L. 387-390, 1895.) As iron replaces manganese in the passage from lithiophilite (Li Mn PO_4) to triphylite (Li Fe PO_4), it is shown that there is an increase in the refractive indices and a gradual change in the size of the optic axial angle, as is seen in the following table, which gives part of the measurements obtained for sodium light.

Locality.	FeO %.	β.	$2V$ over b.	Plane of optic axes.
Branchville, Conn.	4·24	1·675	65° 13′	(001)
Do.	9·42	1·679	62 54	(001)
Do.	13·63	1·682	56 4	(001)
Grafton, N. H.	26·58	1·688	0°	Uniaxial
Rabenstein, Bavaria	35·05	1·702	120°	(100)

The optically positive mineral from Grafton has for thallium light $2V = 21°53'$ in the plane (001), and for lithium light $2V = 15°3'$ in the plane (100). Lithiophilite is optically positive, and the acute bisectrix is perpendicular to (010); the Rabenstein triphylite is optically negative, and the acute bisectrix is perpendicular to (001). On plotting a curve it is seen that a further increase in the amount of iron would cause 2V to become zero again, this time negative with the optic axis perpendicular to (001); and as the pure compound Li Fe PO_4 (which is not known) is approached, it may be expected that the optic axes would open out in the plane (010). L. J. S.

Knopite, a new mineral resembling Perofskite, from Alnö, Sweden. (P. J. Holmquist, *Geol. För. Förh.*, XVI., 78-95, 1894; abstr. in *Neues Jahrb. Min.*, II. 412-416, 1895.) Minerals at first thought to be perofskite and dysanalyte are here described under the new name knopite, of which two types are distinguished.

Type I. This is found as lead-grey crystals of metallic lustre, about 5 mm. across, in crystalline limestone from Långörsholm, and is associated

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with garnet, titano-magnetite, dark green mica and apatite; it also occurs in the serpentine-like masses enclosed in the limestone. The crystals are pseudocubic, and show dull octahedral faces with smaller cube faces which are bright and often conically rounded: there are also small rounded faces between the positions of (811) and (12.1.1), and between (11.2.0) and (920). On the cube faces are seen striations due to the lamellar structure of the crystals, which is well brought out in sections cut parallel to various faces, when viewed by reflected light falling from one side, and resembles that seen in perofskite by transmitted light: the broader lamellæ are perpendicular to (100) and (111), these being built up of finer lamellæ perpendicular to (100) alone. A platy fracture often parallel to (100) is seen in the sections. Very thin sections are translucent and strongly doubly refracting, an eccentric optic axis being seen in places through (100). Fresh crystals have a hardness of 5 – 6, fracture uneven; sp. gr. of the crystals 3·8902, of the purified powder 4·1101. The mineral is decomposed by a mixture of hydrofluoric and sulphuric acids. Analysis gave:—

SiO_2	TiO_2	ZrO_2	FeO	MnO	MgO	Y—earths(?).	Ce_2O_3	CaO	K_2O	Na_2O	H_2O	Total.
1·29	58·74	0·91	3·23	0·31	0·19	0·06	5·80	26·84	0·75	0·29	1·00	99·41

This reduces to RO,TiO_2; ZrO_2 replacing TiO_2, while the silica is considered as an impurity.

Type II. This occurs in the Långörsholm limestone, and also in a breccia, from the nepheline-syenite margin at Norrvik, consisting mainly of serpentine-like masses with apatite, nepheline and some calcite. The small black cubes of knopite have a metallic lustre and show a step-like aggregation; (111) is small, and interpenetrating twins on (111) occur. No lamellar structure is seen on the cube faces. Very thin splinters are translucent, doubly refracting, and pleochroic, and show only traces of lamellæ. H = 5-6, fracture uneven. The mineral from Norrvik has sp. gr. = 4·21 (anal. I.), that from the limestone has sp. gr. = 4·288 (anals. II and III).

	TiO_2	FeO	Ce_2O_3	MgO	CaO	Na_2O K_2O	H_2O	Total.
I.	54·12	4·19	6·81	—	33·32	0·79 0·38	0·21	99·82
II.	56·30	5·15	4·46	0 35	32·22	0·39	0·30	99·17
III.	54·52	4·94	4·42	0·32	32·84	1·68	0·92	99·64

The slight variation from the formula $RO.TiO_2$ is explained by impurities (especially water and alkalies) and decomposition. L. J. S.

Northupite, a new mineral (W. M. Foote, *Amer. Journ. Sci.*, L., 480-481, 1895). This was found by C. H. Northup in clay at Borax Lake

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California, as regular octahedra of a dirty white to dark brown colour. Cleavage imperfect; brittle, with uneven fracture, H = 3·5-4. These are regularly arranged enclosures, probably of organic matter. When heated the mineral blackens and easily fuses. Qualitative analysis shows it to be a double chloride and carbonate of sodium and magnesium, together with traces of phosphoric acid, silica, iron, calcium and organic matter. Boiling water decomposes the mineral, with separation of basic carbonate of magnesium. L. J. S.

Jadeite from Tammaw, Upper Burma (Max Bauer, *Records Geol. Survey India*, XXVIII. 91, 1895, and *Neues Jahrb. Min.*, I., 18-27, 1896). The jadeite of this locality is snow-white with emerald-green spots, the latter containing chromium; sp. gr. varies from 3·338 to 3·325. Analysis by K. Busz gave

SiO_2	Al_2O_3	CaO	MgO	Na_2O	Loss on ignition	Total	Sp. gr.
58·46	25·75	0·63	0·34	13·93	1·00	100·11	3·332

Chromium and iron are absent. This corresponds to 90·1 p.c. of Na_2O, Al_2O_3, $4SiO_2$, 4·59 of MgO, Al_2O_3, $4SiO_2$ and 1·28 of CaO, SiO_2. Under the microscope it is seen to consist of a confused aggregate of irregular prisms with slight pleochroism, and the cleavage and optical characters of pyroxene; extinction angle 40°. Some specimens show marked cataclastic structures, the prisms being bent, fringed at the ends, and showing undulose extinction; sometimes the whole is crushed to small grains with aggregate polarisation. This is associated with secondary twinning on the basal plane, the lamellæ being narrow and numerous, and the mineral closely resembling plagioclase in appearance. L. J. S.

Native Iron from Ontario (G. C. Hoffmann, *Report Geol. Survey Canada*, VI. R. 23-24, 1895). Native iron occurs as small steel-grey spherules in kaolin and limonite in a pegmatite vein at Cameron, District of Nipissing. The spherules are almost perfectly spherical, and vary in size from 1 mm. in diameter down to microscopic dimensions; they are very hard, scratching hardened steel. When dissolved in hydrochloric acid there is a strong smell of phosphine. Analysis by R. A. A. Johnston gave—

Fe	Mn	Ni	Organic matter.	Insol.	Total	Sp. gr.
90·45	0·75	trace	not det.	7·26	98·46	7·257

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Copper and cobalt are absent. The insoluble residue consists of the light brownish nuclei, which have an apparently concretionary structure: it contains 88·77 p.c. of SiO_2 with some Al_2O_3, Fe_2O_3 and CaO. The metallic layer of these spherules is rather thicker than that of the similar spherules from St. Joseph Island, Ontario (Abstr. Vol. X., 50). L. J. S.

Prolectite, a new mineral of the Humite group (H. Sjögren, *Bull. Geol. Inst. Upsala* II. 99-105, 1894). Penfield and Howe have shown (*Amer. J. Sci.* XLVII. 188, 1894) that the members of the humite group have the composition—

Chondrodite	... ...	$Mg_3[Mg(F,OH)]_2[SiO_4]_2$
Humite	... ...	$Mg_5[Mg(F,OH)]_2[SiO_4]_3$
Clinohumite	... ...	$Mg_7[Mg(F,OH)]_2[SiO_4]_4$

In these formulæ the ratio of the number of magnesium atoms is 5 : 7 : 9, and this is also the ratio of the vertical axes of the three minerals, which thus form a morphotropic series. The same authors also predicted the existence of a member of the group having the composition $Mg[Mg(F, OH)]_2SiO_4$, and crystallising either in the orthorhombic or monosymmetric system, with $\beta = 90°$ and $a : b : c = 1·086 : 1 : 1·887$. Later (*Bull. Geol. Inst. Upsala*, II, 39, 1894) Sjögren also deduced the same formulæ as above for the chondrodite, humite and clinohumite of the Ko-mine, Nordmark, Sweden. The occurrence and associations of the humite minerals at this new locality are strikingly similar to those at the Tilly Foster iron mine, N.Y., and in the description (*Bull. Geol. Inst. Upsala*, I. 40, 1892) of their crystallographic and optical characters, Sjögren mentions that some crystals, which are the subject of the present paper, differ from the rest in crystal angles and optical properties. Of these crystals only two fragments were found, which are here described as being monosymmetric with $a : b : c = 1·0803 : 1 : 1·8862$; $\beta = 90°$; the vertical axis is thus one-third of that of clinohumite, and the axial ratios are almost exactly the same as those predicted by Penfield and Howe for a mineral having the composition $Mg[Mg(F,OH)]_2SiO_4$. Owing to lack of material an analysis has not been made of this interesting mineral, which derives its name from προλέγειν, to foretell (see above p. 189).

L. J. S.

Hoeferite, a new mineral of the Chloropal group (F. Katzer, *Tsch. Min. Mitth.*, XIV., 519-525, 1895). This new mineral from Kritz, near Rakonitz, Bohemia, is earthy, and of a siskin-green colour with a fatty

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lustre, H = 1—3. It fuses with difficulty to a black magnetic slag; it is only partially decomposed by strong sulphuric acid, and not at all by HCl or KOH. The material, which contains small quantities of iron sulphate, antimony ochre and arsenic sulphide, was purified by means of dilute acid, and, after being air-dried, gave on analysis—

SiO_2	Fe_2O_3 (and a little FeO)	Al_2O_3	Loss on ignition	Total	Loss at 120°	Sp. gr.
36·14	45·26	1·11	18·15	100·66	0·99	2·27
35·88	46·64		18·20	100·72	3·79	2·41

Formula $2Fe_2O_3.4SiO_2.7H_2O$. The points in which the mineral differs from nontronite, pinguite and other chloropals, are given. Schrauf's analysis of chloropal from Mugrau is reduced to a mixture of hoeferite and $CaO.3SiO_2.4H_2O$. The mineral from Kritz is supposed to have been produced by the action of sulphuric acid, derived from pyrites, on felspar. L. J. S.

Hautefeuillite, a new mineral (L. Michel, *Bull. Soc. Franc. Min.*, XVI., 38-40, 1893). The greyish-white apatite veins in the gabbro of Odegärden contain greenish nodules consisting of a mixture of wagnerite and apatite, in which the new mineral was found with crystals of apatite, pyrites and monazite. The colourless, transparent, monosymmetric crystals form lamellar and radial aggregates; they show the forms 100, 110 and 010, and have a perfect 010 cleavage. Plane of the optic axes, 010, $Bx_a : 100 = 45°$ about; $\beta = 1·52$; $2E$ about 88°; $2V$ 54°23′ for yellow. Sp. gr. 2·435; H 2½.

P_2O_5	MgO	CaO	H_2O	Total.
34·52	25·12	5·71	34·27	99·62

This gives the formula $(Mg,Ca)_3(PO_4)_2$, $8H_2O$. The mineral differs from bobierrite in containing calcium, and in the optical characters.

L. J. S.

Caryinite and Soda-berzeliite (H. Sjögren, *Bull. Geol. Inst. Upsala*, II., 113-121, 1894). The only previous analyses of *caryinite* have been shown to have been made on impure material, mixed with calcite and berzeliite, into the latter of which caryinite is readily altered. A new find of the mineral at the old locality, Långban, Sweden, has rendered it possible to analyse pure, fresh material, and to determine, by means of the cleavage (110 and 010) and optical characters, that the mineral is

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orthorhombic. The massive nut-brown mineral occurs in fissures with schefferite, rhodonite and hedyphane; sp. gr. 4·29; analysis by Mauzelius gave the composition I.—

	As_2O_5	V_2O_5	P_2O_5	PbO	FeO	MnO	MgO	BaO
I.	49·78	trace?	0·19	9·21	0·54	18·66	3·09	1·03
II.	52·90	0·24	—	—	0·38	21·41	0·72	—

	CaO	K_2O	Na_2O	H_2O	Cl	Total
I.	12·12	0·37	5·16	0·53	trace	100·68
II.	18·34	0·09	5·05	0·40	trace	99·53

Analysis II is of *soda-berzeliite*, a new variety of berzeliite, and only distinguished from it in outward appearance by its orange-yellow to fire-red colour; it is usually massive, but sometimes occurs as regular icositetrahedra; sp. gr. 4·21; it contains also traces of Sb_2O_5. These two analyses are very similar, and both reduce to the same formula. If the water exists with the bases as H_2 the formula is deduced as $10RO,3As_2O_5$; if, however, it exists in the group (HO-R″) the formula is $3RO,As_2O_5$. These two minerals may then have different formulæ, or they may have the same formula and be dimorphous, or thirdly, the presence of lead in caryinite may be essential. L. J. S.

Pyronurite from the Moss Mine, Nordmark, Sweden (H. Sjögren, *Bull. Geol. Inst. Upsala*, II, 59-63, 1894). This mineral, which has only been previously described from Långban and from the Shetlands, has been found in the manganiferous dolomite of the Moss mine, as thin, yellow to yellowish-brown, crystal scales with a round or hexagonal outline, and with a pearly to greasy lustre on the basal plane. The forms present are 111, 100, $2\bar{1}\bar{1}$, $5\bar{1}\bar{4}$, and others giving rise to rounding; $100 : 111 = 76°30'$ ($a : c = 1 : 3·6072$). These angles are very near to those of chalcophanite, but as the prism $5\bar{1}\bar{4}$ is only developed with six faces, the crystals are hexagonal with pyramidal hemihedrism, chalcophanite being rhombohedral. Only in very thin crystals is there total extinction and an optically uniaxial figure, other crystals being divided into fields which give biaxial figures. On heating, the mineral is infusible and retains its yellow colour; after ignition it is strongly magnetic, before only slightly so. Sp. gr. 2·07. Analysis by Mauzelius, on a small amount of material dried at 108°, gave

Fe_2O_3	MnO	MgO	H_2O	Insol.	Total
22·0	4·5	34·8	36·1	0·5	97·9

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This nearly agrees with the pyroaurite formula, but with part of the MgO replaced by Mn; namely $Fe_2O_3.6(Mg,Mn)O.15H_2O$. The Långban mineral is opaque under the microscope, indicating decomposition, which is also shown by the presence of carbon dioxide. L. J. S.

Artificial Powellite (L. Michel, *Bull. Soc. Franc. Min.* XVII, 612-614, 1894). On heating to a high temperature a mixture of six parts of sodium molybdate, one of sodium tungstate, three of calcium chloride and two of sodium chloride, translucent, milky-white crystals of powellite were formed; these, which are about 2 mm. across, are octahedral in habit, with the forms $c(001)$, $p(111)$ and $e(101)$; $a : c = 1 : 1{\cdot}5449$. The crystals have an adamantine lustre and are optically positive; analysis gave

MoO_3	WO_3	CaO	Total	Sp. gr.	
62·37	10·23	26·41	99·01	4·61	L. J. S.

Artificial Percylite, Cumengeite and Boleite. (C. Friedel, *Bull. Soc. Franc. Min.*, XV, 96-101, 1892, and XVII, 6-8, 1894.) In the first paper is described the result of the prolonged action of copper chloride solution on lead hydroxide; here a blue crystalline powder was formed, consisting of strongly birefringent tetragonal octahedra having the characters of the tetragonal boleite; with these, but in much smaller quantity, were also cubic crystals corresponding to the cubic variety of boleite. Analysis of the material agreed with the formula Pb(OH)Cl, Cu(OH)Cl, and the name percylite is here given (apparently to both kinds of crystals) to distinguish it from the argentiferous boleite. Subsequently, however, Mallard (*Bull. Soc. Franc. Min.*, XVI, 184, 1893), has given the name cumengeite to the former crystals, though the cubic crystals may still perhaps be considered as being percylite. Phosgenite was also formed in the above reaction. In the experiment described in the second paper a mixture of lead and silver hydroxides, in the same proportion as in boleite, together with clay, took the place of the lead hydroxide; the action of the copper chloride was in this case much slower, and at the end of several months the clay was found to contain blue cubic crystals, blue spherules, and grains of pyrites. The crystals were built up exactly like certain crystals of boleite, consisting of an isotropic cubic nucleus surrounded by six truncated tetragonal pyramids. The crystals were too small in quantity and too impure for analysis, but they certainly differ from those formed without the intervention of silver, and are to be considered as boleite. L. J. S.

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Boleite from Broken Hill, N.S.W. (A. Liversidge, *Journ. and Proc. Roy. Soc. N.S.W.*, XXVIII, 94, 1894). Boleite has been found at the Broken Hill South Mine associated with hæmatite and quartz; it occurs as cubes of an indigo-blue colour with a strong vitreous lustre. Small {111} and {110} planes are also present, and there is a nearly perfect cubic cleavage, as well as an imperfect octahedral cleavage. The cubes measure 4—7 mm. along the edge, and interpenetrate like cubes of fluor-spar. Brittle, H = 3½; sp. gr. = 5·02.

Analysis by Carmichael and Armstrong gave:

Ag	Pb	Cu	Cl	O (calcd.)	H_2O (calcd.)	Total.
8·25	47·20	19·20	13·50	[6·10]	[5·44]	99·69

This agrees closely with the analysis of the original boleite. A direct determination of the water by Liversidge gave 6·39 per cent., which may be a little too high. L. J. S.

Origin and composition of Onyx Marbles (G. P. Merrill, *Smithsonian Report (U.S. National Museum) for* 1893-4, 539-585, plates 1-18, 1895). Certain travertines and cave deposits of calcium carbonate, which are characterised by being banded and translucent are the so-called onyx marbles or oriental alabasters; they are here shown (by their specific gravity) to consist in almost all cases of calcite, and not of aragonite. Although it is known that such substances are deposited from solution on loss of carbon dioxide, it is not known what controls (except it be the rate of deposition) the character of the deposit as regards compactness and condition of crystallisation, the result being sometimes a compact marble, sometimes a light, tufaceous sinter. The true onyx marbles are superficial deposits from hot springs, and, according to the view taken by the author, deposition has taken place slowly at the bottom of pools of water. The compact nature cannot be explained by the subsequent metamorphism of loose tufas, as such tufas alternate with the marbles. Cave marbles (*i.e.* stalactites, &c.) differ from travertines in being cold water deposits, and in being of greater purity, the water having contained only calcium carbonate in solution, which is not the case with hot springs. These consist sometimes of radially fibrous aragonite, sometimes of silky lustre, but more commonly of calcite, which is of a more granular texture than the aragonite: sometimes both minerals occur in the same cave, but they then belong to different periods of deposition.

In the onyx marbles the content of $CaCO_3$ is rarely below 90 per cent., iron oxide and carbonate being the next prominent constituents, these

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being the main cause of the wide range in colour. The pale and green colours are associated with ferrous carbonate, and the red-browns with ferric oxide, which latter has been produced by the oxidation of the carbonate along cracks and joints; *e.g.* a green marble with 4·27 per cent. $FeCO_3$, contained in the brown-red (oxidised) portions 1·22 per cent. $FeCO_3$ and 3·53 per cent. Fe_2O_3. Some of the colour variations may be partly due to manganese, and in some amber brown and yellow marbles (and one rose-coloured) and in all stalactitic marbles, they are due to organic matter; they are rarely due to mechanical enclosures, such as clay. Small quantities of calcium phosphate and sulphate and $BaCO_3$ and $SrCO_3$ are sometimes present.

The marbles are holocrystalline, sometimes granular, but more often fibrous or radially columnar in structure, the length of the fibres being parallel to the principal axis of calcite, and arranged perpendicularly to the planes of deposition (*i.e.* banding). The specific gravity varies from 2·64 to 2·79 and the hardness 3 to 3·5; only in one case was the sp. gr. as high as 2·87, with H = 4, this being the only aragonite in the whole series examined. The uses, ancient and modern, and the occurrences of onyx marble, are described at length in the paper.

L. J. S.

Kauaiite, a new mineral from Hawaii. (E. Goldsmith, *Proc. Acad. Nat. Sci. Philadelphia*, 1894, 105-107). This volcanic product is white or faint cream coloured, and is dull and powdery, closely resembling chalk in appearance. Under the microscope it is seen to consist of granules all of about the same size, and is pale blue by transmitted light. Sp. gr. 2·566. When heated it gives off an oily substance and acid water. It is soluble in acids only after ignition, but is dissolved by caustic alkali. Eliminating about 5·94 per cent. of carbonaceous matter, the results of the analysis are:—

Al_2O_3	K_2O	Na_2O	H_2O	SO_3
39·79	7·37	1·72	33·56	17·55

This gives the formula $2Al_2O_3,3(K,Na,H)_2O,SO_3$ This highly basic sulphate is distinguished from others by being insoluble in acids.

L. J. S.

Retzian (Hj. Sjögren, *Bull. Geol. Inst. Upsala*, II, 54-59, 1894). This new arsenate occurs as crystals in cavities in a mixture of braunite and dolomite at the Moss mine, Nordmark, Sweden. It is of a chestnut to

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chocolate-brown colour; streak light brown; lustre vitreous, approaching to greasy; subtranslucent. The crystals are orthorhombic with a prismatic or thickly tabular habit; forms, in order of prominence, $b(010)$, $c(001)$, $m(110)$, $d(101)$, $n(130)$. There is no cleavage. The plane of the optic axes is parallel to b; strongly pleochroic, the colour varying from crimson to orange-yellow. Sp. gr. 4·15; H about 4. The analysis is incomplete owing to lack of material; a constituent (amounting to 10·3 per cent.), separated from the manganese precipitate, not having been identified.

As_2O_5	PbO	FeO	MnO	CaO	MgO	SiO_2	H_2O	Insol.
24·4	0·2	1·7	30·2	19·2	2·7	0·5	8·4	4·3

From this analysis it is seen that the mineral is closely allied to other hydrous manganese arsenates (allactite, synadelphite, diadelphite, hæmafibrite) from the same mine, and to flinkite from the Harstig mine; none of these, however, contains any calcium. Of these it comes nearest to allactite (monosymmetric) and hæmafibrite (orthorhombic) in not containing Mn_2O_3 or other sesquioxides, but the crystallographic constants and strong pleochroism distinguish it from the latter. The ratios of the parameters come near to those of flinkite, but there is a difference in the optic orientation of the two minerals. L. J. S.

Urbanite, a new Pyroxene (Hj. Sjögren, *Geol. För. Förh.*, XIV, 251-3, 1892; and *Bull. Geol. Inst. Upsala*, II, 77-87, 106-8, 1894). The mineral, which occurs as veins in hæmatite at the Långban mines, Sweden, was first examined by Breithaupt in 1865, it being then considered to be identical with the schefferite from the same locality. In drusy cavities brilliant brownish-black or black crystals have been found; these present, as more important forms, $a(100)$, $b(010)$, $m(110)$, $u(111)$, $s(11\bar{1})$, $r(053)$; $c(001)$ being absent: the predominating forms u and s give rise to an octahedral habit, which is very different from that of schefferite or of iron-schefferite.

$$a : b : c = 1·1009 : 1 : 0·6058\,; \quad \beta = 72°7'$$

These constants indicate an approach to acmite rather than to schefferite, as also do the optical constants, the extinction angle $a : c'$ on b being 16° in the obtuse axial angle β. There is the usual prismatic cleavage of pyroxene, with one parallel to the base, $c(001)$, less distinct. The crystals are somewhat translucent: streak light-brown. The pleochroism is strong, the colour varying from brown to light-yellow.

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Sp. gr. 3·52. The analysis I corresponds to the metasilicate formula $(Ca,Mg)O,SiO_2+Na_2O,Fe_2O_3,4SiO_2$, the first part representing diopside and the second part acmite. The high percentage of Fe_2O_3 and of alkalies distinguishes the mineral from schefferite.

	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	CaO	MgO	K_2O
I. Långban	51·61	—	0·74	27·24	0·54	1·73	4·90	2·75	0·36
II. Glakärn	49·21	0·06	1·27	25.35	0·50	6·71	5·68	1·39	0·40

	Na_2O	H_2O	F	Loss on ignition (probably water)	Total
I.	10·59	—	—	0·90	101·36
II.	8·95	1·05	0·20	—	100·69

Igelström's "*lindesite*" from the Glakärn Mine, Örebro (*Abstr.* XI, 105), has been re-analysed by Mauzelius, whose results are given under II, from which a similar formula to the above is deduced, namely $(Ca,Mn)O.SiO_2+Na_2O.Fe_2O_3.4SiO_2$; this represents a rhodonite with an acmite molecule. The mineral occurs at this locality as chestnut-brown coloured grains in a mixture of rhodonite and felspar, which forms veins in the manganese ores jacobsite and braunite. There are two distinct cleavages, with an angle of approximately 96°30′, and also one less distinct. The optical properties are as before; extinction angle $a : c' = + 22°$. Sp. gr. 3·53. L. J. S.

Lorandite. (J. A. Krenner, *Math. és Természett. Értesitö*, XII, 471, 1894, and *Ber. aus Ung.*, XII. 262, 1895). A short notice of this new mineral has already appeared (XI, 32). The tabular or short prismatic crystals are of a cochineal to kermesite-red colour, they are transparent, and can be bent like selenite.

$$a : b : c = 0{\cdot}85339 : 1 : 0{\cdot}66500\,;\quad \beta = 90°17'$$

Forms: (100) (001) (120) (540) (101) (10$\bar{1}$) (011) (111) (11$\bar{1}$) (12$\bar{1}$) (321) (545) (52$\bar{1}$) (54$\bar{1}$). The cleavage is 10$\bar{1}$, perfect, and 101 and 100 very good. Analysis gave:—

S.	As (calcd. from loss).	Tl.
19·02	(21·47)	59·51

Formula $TlAsS_2$. Occurs on realgar at Allchar, Macedonia; rare.

L. J. S.

Xiphonite, a new amphibole from Etna. (G. Platania, *Atti e rendiconti dell' Accad. di Scienze &c., di Acireale*, N. Ser. V, 55-62, 1893;

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abstract in *Neues Jahrb. Min.*, II, 236, 1895). This occurs as small, honey-yellow transparent crystals, in the drusy cavities of a slaggy lava. It is monoclinic with the forms $a(100)$, $b(010)$, $c(001)$, $m(110)$, $e(130)$, $x(150)$, $t(101)$, $p(\bar{1}01)$, $r(011)$, $i(031)$; $mm = 58°15'$. The crystals are prismatic in the direction of r; cleavage m distinct. Plane of the optic axes b; extinction angle 13°. It is supposed, together with the accompanying hæmatite, to have been formed by sublimation. On account of the feeble pleochroism, the light colour, and the special mode of occurrence, it is considered to be a distinct variety of hornblende.

L. J. S.

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Instructions for the Use of Plates I. and II., representing some Nets for Homogeneous Structures.

(1) Several copies of every figure should be made, and each of these after being cut out, should be folded along the dotted lines, and fitted up so as to form a regular solid.

(2) The similar solids thus obtained should be fitted together symmetrically without interstices.

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THE MINERALOGICAL MAGAZINE

AND

JOURNAL

OF THE

MINERALOGICAL SOCIETY.

No. 52. MAY 1897. Vol. XI.

Note on the Occurrence of Rocks allied to Monchiquite in the Island of Fernando Noronha.

By G. T. Prior, M.A., F.G.S., Assistant in the Mineral Department of the British Museum.

[Read February 4th, 1896.]

THE name of Monchiquite, first applied by Rosenbusch and Hunter (*Tscherm. Min. Mitth.* XI. 1890, p. 445) to a peculiar group of dyke rocks found in association with elæolite-syenite in Brazil, is rapidly becoming familiar to petrologists through the discovery of similar rocks from various other localities.

The Brazilian Monchiquites were described by Rosenbusch as black to grayish-black rocks, consisting of porphyritic olivine and pyroxene, with widely varying amounts of hornblende and mica, in a glassy[1] base usually crowded with hornblende microliths.

[1] Recently (*Journ. Geol.* IV. 1896, No. 6) L. V. Pirsson has brought forward evidence to show that the supposed glassy base in these rocks really consists of analcite.

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In the United States similar rocks have been found in many localities, where they occur associated with elæolite-syenite as in Brazil. Rocks belonging to this type in Arkansas were divided by J. F. Williams into Monchiquites proper, containing olivine, and two varieties free from olivine, fourchite (containing augite and hornblende), and ouachitite (containing biotite, or biotite and hornblende). In Arkansas, the Lake Champlain district, and near Montreal, as well as in Brazil, the Monchiquites occur in association with rocks of great geological age. This group, however, is not confined to the older rocks. In the Bohemian Mittelgebirge rocks which are referred to Monchiquite by Rosenbusch occur as dykes in association with the Tertiary phonolites and nepheline basalts. Many of these rocks have been recently investigated by Hibsch (*Tscherm. Min. Mitth.* XIV. 1894, p. 95; and XV., 1895, p. 201.) They were originally described, however, more than 20 years ago by Boricky (*Petrog. Studien a. d. Phonolithgesteinen Böhmens*, 1873; and *Petrog. Studien a. d. Basaltgesteinen Böhmens*, 1874) under the name of trachybasalts. According to Boricky they occur in the form of wall-like dykes, 1 to 3 feet wide, in the phonolites of the north part of the Bohemian Mittelgebirge between Aussig and Tetschen, and are the youngest eruptive rocks in the district. He divides them into three groups, according to the prevalence in them of felspar, nepheline (leucite) and nosean; but all are characterised by a peculiar type of microstructure, viz. the interlacing hornblende microliths in a more or less glassy base. They are mostly free from olivine, and can therefore be referred to the fourchite variety of Williams.

It is to these trachybasalts of Boricky that the rocks from Fernando Noronha, which are the subject of the present note, present the most striking similarities both in character and mode of occurrence. The rocks in question form part of a collection made by Mr. H. N. Ridley during his stay upon the island of Fernando Noronha in 1887 (see *Journ. Linn. Soc.* XXVII. 1891, p. 1). For some of these specimens there is no record of their mode of occurrence; but in the case of the specimens from Sponge Bay, on the south-east side of the main island, it is clearly stated in Mr. Ridley's notes that they occurred as dykes, up to 3 feet in width, running down from the East Hills (Morro Francez) to the sea, and traversing beds of phonolitic tuff. Examination of the sections of some of these rocks suggested at once comparison with the sections of Boricky's trachybasalts in the British Museum collection.

The specimens collected between Cotton Tree Bay and Look-out Hill (Atalaia Grande) in section most resemble the Bohemian rocks. One

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variety (specimens numbered 67 106, −112, −116, −117) is a gray rock, showing to the naked eye, in a dense groundmass, porphyritic prismatic crystals of hornblende and augite. Under the microscope the groundmass is seen to consist of a colourless base (mainly isotropic, but in patches feebly depolarising), which is densely crowded with long microliths of augite and brown hornblende, often arranged in radiating groups, and with small magnetites. The phenocrysts are long prismatic deep reddish-brown hornblendes, generally twinned, and prismatic purple pleochroic augites, often with green or colourless centres. Nosean in hexagonal sections also occurs; but in these specimens the mineral has suffered zeolitic alteration. Included in the hornblendes and augites are octahedra of magnetite, and apatite in needles or in clear sharply-defined hexagonal sections.

Another variety from the same locality (No. 67113) is a dense black glassy-looking rock, showing porphyritic crystals of hornblende and augite. Under the microscope it is seen to be much more like the preceding variety than the hand specimen would suggest. The phenocrysts are the same, viz. hornblende and augite with magnetite, apatite and nosean. In this case the latter mineral is quite fresh and perfectly isotropic, while many of the hexagonal sections show the characteristic inclusions. In the groundmass, which has the appearance of being a more perfect glass (but see Pirsson, *loc. cit.*) than in the preceding rock, the microliths are much more minute, and show flow structure. In a petrographical paper (*Am. J. Sci.* 37, 1889, p. 178) by G. H. Williams, on a collection of rocks from Fernando Noronha made by J. C. Branner in 1876, the augitite (No. 115) from the tuff east of Morro Francez, according to the description, closely resembles the above rock, except that it contains nepheline instead of nosean.

A third variety (No. 67111), occurring as a dyke at the base of Look-out Hill (Atalaia Grande), is a black glassy-looking rock with porphyritic augites and brown patches of altered olivine. Under the microscope it is seen to differ from the rocks described above by the absence of phenocrysts of hornblende and nosean, and by the presence of olivine. The only phenocrysts are large purple zoned augites and altered olivines. These occur in idiomorphic crystals in an extremely dense groundmass, which is almost opaque except in the thinnest possible sections, and consists of an isotropic base, densely crowded with magnetite and minute microliths of augite and hornblende.

The specimens (Nos. 67063 and 67081) from the dykes at Sponge Bay which run down from the East Hills (Morro Francez) to the sea, closely

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resemble the rock (No. 14) described by G. H. Williams *(loc. cit.)* as limburgite, which occurred as a dyke at the base of Atalaia Grande. They are dense black glassy-looking rocks showing porphyritic crystals of augite and hornblende with brown patches of altered olivine. Under the microscope the groundmass is seen to consist of an isotropic base, crowded with long microliths of hornblende and augite, with much magnetite. The phenocrysts are mostly augites in prismatic crystals, green in the interior with purplish brown borders. Hornblende crystals are not numerous, but are large with corroded borders, and in some cases they enclose augites. A characteristic feature of the rock is the numerous hexagonal sections of beautiful blue hauyne. Olivine occurs sparingly in altered crystals.

The rocks above described have all been characterised by the absence of felspar. A specimen (No. 67072), however, from a dyke at Sponge Bay, traversing phonolite, shows the presence of felspar in the groundmass. It is a dense black rock not markedly porphyritic, in parts minutely vesicular. Under the microscope the phenocrysts are seen to consist almost entirely of augites, having the same characters as in the preceding rocks, except that they are not so prismatic and vary in size so that the rock is not so distinctly porphyritic. Besides the augite, deep brown hornblende phenocrysts occur sparingly, and a few small altered olivines. The base is in parts isotropic, and in parts consists of lath-shaped felspars: it is crowded with deep brown hornblende microliths with magnetite and small purplish augites.

A specimen (No. 67083) from the hill above Sponge Bay, and another from Morro Branco (67125), approach more nearly to felspar-basalts. In external aspect they are very similar to the rock (No. 67106) first described, and show large porphyritic crystals of hornblende and augite in a light gray groundmass. In section the groundmass is seen to consist of an isotropic base containing small lath-shaped felspars, granular augite and much magnetite. The phenocrysts are large prismatic augites and hornblendes, sometimes intergrown.

In the present note only a brief account of this group of rocks has been given, mainly with the view of pointing out the analogies which they present in character and geological occurrence with the Tertiary igneous rocks of the Bohemian Mittelgebirge. In both localities we have these Monchiquite dykes associated with phonolites and nepheline-basalts. In Fernando Noronha the relative age of phonolite and nepheline-basalt has not been satisfactorily made out. Professor Branner was unable to come to any definite conclusion on this point. Mr. Ridley, from the

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appearance of alteration of phonolite by basalt in certain localities, considered that the phonolite was anterior to the basalt. It may be pointed out, however, that the localities he mentions (Look-out Hill, Morro Branco) are just those in which Monchiquites occur, and that the basalts he speaks of may belong to these exceptional rocks rather than to the nepheline-basalts which constitute the prevailing rocks of the island. As in Bohemia, so in Fernando Noronha, the phonolite is found occupying the prominent peaks (Mount St. Michael, the Peak, Atalaia Grande, etc.), and has the appearance of having been injected into older rocks. We are inclined, therefore, to venture the opinion that the sequence of the rocks in Fernando Noronha will be found to be the same as in the Bohemian Mittelgebirge, viz. nepheline-basalt, phonolite, trachybasalt, and that in both localities these youngest Monchiquite dykes represent the later stages in the differentiation of an elæolite-syenite magma.

In a future paper I hope to give a more detailed account of these and other rocks from Fernando Noronha, and to supplement that account with analyses of the principal types.

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On Derbylite, a new Antimono-titanate of Iron, from Tripuhy, Brazil.

By Dr. E. Hussak, of the Geological Survey of S. Paulo; and
G. T. Prior, M.A., F.G.S., Assistant in the Mineral Department of the British Museum.

[Read February 2nd, 1897.]

A BRIEF notice of this new mineral, which was found associated with Lewisite in the cinnabar-bearing sands of Tripuhy, near Ouro Preto, Minas Geraes, Brazil, has already been given by the authors in *Min. Mag.* Vol. XI. No. 50, p. 85. Since that time a sufficient amount of material (1½ grms.) has been separated from the sand to permit a more detailed investigation of its crystallographic and chemical characters.

Crystallographic and other physical characters (E. H.).

Derbylite crystallises in the orthorhombic (holohedral) system.

Axial ratios: $a : b : c = 0{\cdot}96612 : 1 : 0{\cdot}55025$.

Fundamental angles: $100 : 110 = 44° 0' 45''$.

$001 : 011 = 28° 49' 18''$.

Observed forms: $\infty P(110)$ *m*, $\infty \bar{P}\infty$ (100) *a*, $0P(001)$ *c*.

The prism faces are very smooth and brilliant, while the macropinacoid is for the most part rough. The rare basal plane is always uneven and arched, and a conchoidal fracture parallel to this plane is frequently observed. Terminal faces are lacking, and the inclination 001 : 011 is calculated from the twinning law.

Twinning (see Figure) is frequent, giving staurolite-like contact and intergrowth forms according to the law:—twinning plane a face of (011), whereby the vertical axes of the two individuals cross at an angle of 57° 38′ 36″, and the macropinacoids of both individuals fall into the same plane; the angle between two adjacent prism faces of the two individuals was measured as 39° 8′ 25″. From these angles the value of 001 : 011 was calculated as 28° 49′ 18″.

Triplets according to the same law also occur, but are rare.

Colour: pitch black, translucent in thin splinters, with a dark brown tint.

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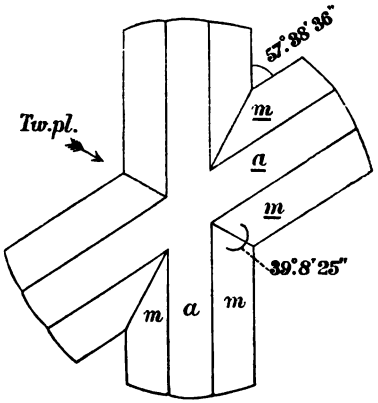
Lustre: resinous, especially well shown on fractures parallel to 001.

Hardness: about 5, not determinable with exactness on account of the minuteness of the crystals and their extreme brittleness, due to the conchoidal fracture parallel to 001.

Optical Properties. These also proved indeterminable in the thinnest section which could be prepared by the well-known firm of Voigt and Hochgesang in Göttingen. The mineral is translucent in extremely thin splinters only, and on these the only points determinable were that it is biaxial, and not notably pleochroic.



Specific Gravity (G. T. P.). A determination made with a 3cc. pyknometer upon 0·7549 grm. gave as the weight of 1cc. at 18°, 4·530. Two previous determinations made on different samples in much smaller amount (0·1121 grm. and 0·1945 grm. respectively) gave 4·529 and 4·512.

Chemical Characters (G. T. P.).

Derbylite is insoluble in acids, but is decomposed by fusion with acid sulphate of potassium. With salt of phosphorus it gives in the reducing flame a bead, yellow when hot, violet when cold.

Two quantitative analyses have been made. For the preliminary analysis, No. I., only 0·1281 grm. was available; for the second, more complete, analysis, No. II., 0·5263 grm. was used. Unfortunately the material for the analyses could not be completely freed from a white adhering impurity.

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Result of Analyses.

I.		II.		Molecular Ratios.
Sb_2O_5	19·0	Sb_2O_5	24·19	·075
TiO_2	35·8	TiO_2	34·56	·420
SiO_2	3·1	SiO_2	3·50	·058
		Al_2O_3	3·17	·031
FeO	33·9	FeO	32·10	·447
CaO	· 0·4	CaO	0·32	·006
		Na_2O	0·76	·012
		K_2O	0·28	·003
Loss on ignition	0·5	Loss on ignition (from I.)	[0·50]	
Undetermined (partly loss of Sb_2O_5)	(7·3)			
	100·0		99·38	

If the SiO_2, Al_2O_3 and alkalies be not regarded as essential constituents but as due to impurity, the simplest formula *suggested* by the numbers obtained in Analysis II. is $FeO.Sb_2O_5 + 5\ FeO.TiO_2$.

Method of Analysis. In both analyses the mineral was decomposed by heating in a current of hydrogen. The reduced material was digested with a mixture of nitric and tartaric acids, to which hydrochloric acid was added later in order to expel the nitric. A considerable amount of a black residue remained undissolved. This consisted mainly of Ti_2O_3, but retained some iron and antimony. In the preliminary analysis the insoluble residue was collected on a filter and was afterwards ignited, so that some loss of antimony certainly occurred. In the second analysis, therefore, the insoluble residue was transferred to a silver crucible and fused with caustic soda. The product was dissolved in a mixture of hydrochloric and tartaric acids, and treated separately from the original solution, though in a similar way. The antimony was precipitated by sulphuretted hydrogen, and the iron in the filtrate by ammonium sulphide. After the destruction of the tartaric acid, the titanium was precipitated by ammonia and the calcium with ammonium oxalate. After weighing, the titanic acid mixed with silica and alumina was fused with acid potassium sulphate and the silica separated. The titanium in the solution was then precipitated by long continued boiling, and the alumina in the filtrate by ammonia.

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Mode of occurrence of Derbylite (E. H.). The mineral was found in the cinnabar-bearing gravel of the fazenda Tres Cruzes, Tripuhy, near Ouro Preto, Minas Geraes, Brazil. The minerals accompanying it, including Lewisite, have been already noted in this Magazine (*loc. cit.*). The Derbylite was first found in loose crystals, from 2 to 3 mm. long, and in fragments of crystals, in the sand. The crystals had often intergrowths of muscovite on the ends of the prisms, being in this respect similar to Lewisite, which often shows inclusions of quartz grains and flakes of muscovite. Later observations prove that both minerals come from the thin bedded muscovite-schist which accompanies itabirite in the neighbourhood of Tripuhy, and recently both these titano-antimonates have been found *intergrown* with specular iron in fragments of this *muscovite-schist* found in the gravel.

The name of Derbylite has been given to the mineral after Orville A. Derby, Director of the Geographical and Geological Survey of the State of S. Paulo, Brazil, in commemoration of his great services in the Geology of Brazil.

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On the Chemical Composition of Zirkelite.

By G. T. Prior, M.A., F.G.S.,

Assistant in the Mineral Department of the British Museum.

[Read November 17th, 1896.]

In a previous paper (*Min. Mag.* XI. 1895, p. 80), the result was given of an analysis of the new mineral, Zirkelite, which was discovered by Dr. Hussak in association with baddeleyite in the decomposing magnetite-pyroxenite of Jacupiranga, S. Paulo, Brazil.

In that analysis only a small amount of material (less than a quarter of a grm.) was used, and no very serious attempt was made to separate small percentages of rare earths in the main zirconia precipitate. The individual numbers also which resulted from an attempt to separate the titanium and zirconium by Bailey's hydrogen peroxide method were given provisionally, and stated to be regarded only as approximate. A subsequent examination of the precipitates showed that the mineral contained cerium, and that (owing mainly to the impurity and want of concentration of the hydrogen peroxide employed) the attempt at separating the titanium and zirconium had been a failure, so that the number giving the percentage of titanium was much too high. A note to this effect would have been inserted in this Magazine had no further material been available for analysis; but, fortunately, through the zeal of Dr. Hussak, a larger supply of the mineral was soon forthcoming, sufficient for the more complete analysis, of which the result is given below.

In this analysis only material which sank in thallium-silver nitrate was used.

A re-determination of the density, made on ·6893 grm. of such material, gave as the weight of 1cc. at 17° C. 4·741.

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Result of Analysis : —

		Molecular ratios.
ZrO_2 =	52·89	·433
TiO_2 =	14·95	·182
ThO_2 =	7·31	·028
Ce_2O_3 =	2·52	·008
(Y_2O_3 ?) =	0·21	·001
UO_2 =	1·40	·005
FeO =	7·72	·107
CaO =	10·79	·193
MgO =	0·22	·005
Loss on ignition (from preliminary analysis) =	1·02	
	99·03	

Weight of material used in analysis, 0·4716 grm. The molecular ratios correspond approximately to the formula $RO.2(Zr,Ti,Th)O_2$.

Method of Analysis.—The mineral (very finely powdered by grinding in an agate mortar and moistening with absolute alcohol) was decomposed by fuming hydrofluoric acid.[1] By diluting and filtering, a rough separation was at once effected between the soluble (Zr,Ti,Fe...) and the insoluble (Th,Ca,Ce...) fluorides. The solution (A) and the insoluble residue on the filter (B) were then treated separately.

(A) The solution was evaporated nearly to dryness, and the fluorides decomposed by sulphuric acid, the excess of which was removed by heating gently. On adding cold water, a clear solution was obtained. After nearly neutralising with sodium carbonate, the Zr and Ti were precipitated by sodium thiosulphate, and the Fe in the filtrate, after separating sulphur, by ammonia. After weighing, the mixed ZrO_2 and TiO_2 were again brought into solution, and the TiO_2 determined by Weller's colorimetric method (*Ber. Deutsch. Chem. Ges.* XV. 1882, p. 2592).

(B) The insoluble fluorides were decomposed by sulphuric acid, and the resulting sulphates brought into solution in cold water. In this solution hydrogen peroxide failed to produce any coloration, thus showing the absence of TiO_2. On boiling, however, a precipitate (ThO_2) was deposited. This was filtered hot, washed, dried and weighed. Its weight was ·0294 grm., corresponding to 6·2 p.c. In the filtrate the Ce_2O_3, &c. was

[1] Lawrence Smith, *Original Researches in Mineralogy and Chemistry*, p. 352.

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separated from CaO by a double precipitation with ammonia. On testing the moist ammonia precipitate with dilute hydrofluoric acid, a large proportion was found to be soluble (some ZrO_2 had been retained in the insoluble fluorides). The hydrofluoric acid was expelled by sulphuric acid, and the solution reprecipitated by ammonia. This precipitate was washed, dried and weighed. It was then, together with the ThO_2 precipitate, again brought into solution by fusion with acid sulphate of potassium. From this solution a precipitate was obtained by means of sodium thiosulphate, which on ignition weighed ·0646 grm., corresponding to 13·70 p.c. In the filtrate the cerium and uranium were precipitated by ammonia; this precipitate was redissolved and the cerium separated by precipitation with oxalic acid. The filtrate was evaporated to dryness and ammonia salts expelled before precipitating the uranium. A small portion of this precipitate gave with microcosmic salt a good uranium bead. The oxalic acid precipitate (Ce_2O_3) was ignited and weighed. It was again brought into solution, and the Ce_2O_3 precipitated by potassium sulphate. In the filtrate, oxalic acid gave a slight precipitate, which, on ignition, yielded an oxide (Y_2O_3?), only faintly yellow, and thus distinct from the reddish-buff oxide (CeO_2) obtained from the potassium sulphate precipitate.

The sodium thiosulphate precipitate was found to consist of almost equal parts of ThO_2 and ZrO_2. After ignition and weighing, it was brought into solution by means of hydrofluoric and sulphuric acids. The solution was divided into two equal parts, and each treated separately. In one part the sulphuric acid was neutralised by potash, and the ZrO_2 and ThO_2 thrown down by boiling with potassium sulphate. From this precipitate hydrochloric acid separated the ThO_2, leaving most of the ZrO_2 undissolved. The hydrochloric acid solution was evaporated to dryness. The residue gave a clear solution with cold water, from which the ThO_2 was precipitated by oxalic acid added in considerable excess. The other half of the solution of the thiosulphate precipitate was treated with ammonia until a permanent precipitate formed; oxalic acid in excess was then added. A clear solution resulted, but on adding hydrochloric acid most of the ThO_2 was precipitated. The filtrate from the precipitate was evaporated to dryness, and the ammonia salts expelled. The residue was dissolved in hydrochloric acid, the excess of acid expelled, and the remainder of the ThO_2 precipitated by excess of oxalic acid. The ZrO_2 in the filtrate was precipitated with ammonia. The combined ThO_2 precipitates, after ignition and weighing (·0313 grm.), were dissolved in sulphuric and hydrofluoric acids, the solution evapo-

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rated to dryness, and the excess of sulphuric acid expelled: the residue was dissolved in cold water, and the ThO_2 again precipitated with excess of oxalic acid. The resulting oxide weighed 0·0299 grm., and gave a sulphate weighing 0·0492 grm., corresponding to a molecular weight of about 250.

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The "Satin Spar" of Alston in Cumberland; and the Determination of massive and fibrous Calcites and Aragonites.

By L. J. Spencer, M.A., F.G.S.,
Assistant in the Mineral Department of the British Museum.

[Read February 4th, 1896.]

OWING to the fact that aragonite frequently occurs in fibrous aggregations, as in "flos ferri," it seems to have been sometimes assumed that all fibrous specimens of calcium carbonate are aragonite.

On these grounds the "satin spar" from Alston Moor in Cumberland is often referred to aragonite, although it has more than once been shown to be really calcite. Miller[1] refers to it under aragonite, as being from "Dufton in Cumberland,"[2] saying that it contains 4·25 per cent. of manganese carbonate: these figures are those given by J. Holme[3] in a very crude analysis of the satin spar of Alston. This error is copied from Miller into Greg and Lettsom's *British Mineralogy* and into Dana's *System of Mineralogy*. The mineral in question seems to have been first definitely determined by A. Aikin, who published an account of it in 1802 in the Proceedings of the British Mineralogical Society.[4] Here an analysis is given, and the density determined as 2·709—2·721, the mineral being placed amongst other varieties of calcite. J. Holme in his analysis[5] found no water, which he supposed to be essential to aragonite. G. Rose,[6] from his determination of the hardness and specific gravity (2·720; in powder 2·724), points out that the mineral is calcite, and not

[1] *Min.* p. 569.

[2] Dufton is in Westmoreland.

[3] *Trans. Linnæan Soc.* XI. 164, 1815.

[4] Tilloch's *Phil. Mag.* XII. 364, 1802. The British Mineralogical Society, referred to above, was started in 1799; references to it are to be found in the *Phil. Mag.* VI. 369, 1800; IX. 282, 1801; XII. 284, 1802; XIV. 289, 1802; XIX. 85, 1804. The objects of the society were especially connected with the mineralogy of the British Isles. The society seems to have fallen through shortly before the foundation of the Geological Society in 1807, and in the first list of the latter society are to be seen the names of many of the 25 members, mineralogical papers by whom were published in the Transactions of the Geological Society.

[5] *Loc. cit.*

[6] *Abhandl. Akad. Berlin*, pp. 7, 11, 1856.

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aragonite. The Comte de Bournon, in his *Traité de la Chaux Carbonatée* (I. 166), also describes it under calcite.

The Alston satin spar occurs in straight, regular veins, two or three inches across, in a black shale of Carboniferous age, containing also veins of decomposing pyrites; the veins are parallel to the lamination of the shale. It is of a snow-white colour, with sometimes a delicate rosy tinge, and has a satiny lustre which is strongly brought out on surfaces parallel to the fibre when highly polished. The mineral consists of an aggregation of long, very fine fibres, quite straight and parallel, and arranged perpendicularly to the sides of the vein; it is quite distinct from the coralloidal aragonite of Dufton in Westmoreland, which also has a more or less satiny lustre, but not nearly so marked as in the Alston mineral.

When a fragment is finely crushed and examined under a $\frac{1}{12}$ inch immersion in oil, long, thin, cleavage rhombs of calcite are seen, the directions of optical extinction bisecting the cleavage angles, and thus being oblique to the length of the fibre. In convergent polarised light the usual eccentric uniaxial interference figure of a calcite cleavage flake is seen. The fibres of the satin spar, therefore, consist of calcite crystals enormously elongated in the direction of one of the edges of the primitive rhombohedron. A thin section cut at about 45° to the length of the fibres did not show any interference figure near the centre of the field, as would be expected; this, however, was due to the overlapping of the very fine fibres, which also for this reason did not show any definite extinction. Des Cloizeaux[1] mentions that the fibres are excessively fine, and not sufficiently transparent to have any marked action on polarised light. A thin section cut perpendicular to the fibres showed small interlocking areas of irregular outline, but longer in one direction than in the direction at right angles; each gave definite extinction, but in various directions for the different areas, giving the whole section, as seen between crossed nicols, the appearance of a mosaic. The specific gravity of the fine powder was roughly determined as 2·70.

In fibrous calcite the direction of optical extinction is usually parallel to the length of the fibre, showing that we are here dealing with crystals elongated in the direction of the trigonal axis. The direction of elongation parallel to one of the edges of the primitive rhombohedron seems to be rather unusual for calcite; but an approach to it is sometimes seen in

[1] *Manuel de Min.* II, p. 118.

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the isolated crystals of "Iceland spar" from Iceland, which show $r(100)$ with narrow $v(20\bar{1})$ and $w(410)$, and have sometimes a length three or four times the breadth and seven or eight times the thickness, as measured along the rhombohedron edges. Calcite of the same habit as the Alston satin spar, that is occurring in veins, and consisting of straight parallel fibres elongated parallel to a rhombohedron edge, has been noticed in specimens from Andrarum, Skåne, Sweden, and from Neutitschein, Moravia; the former occurs in a black alum-shale with veins of pyrites, and is strikingly similar to the Alston occurrence; the latter occurs in serpentine; the fibres of both are, however, too coarse to show any marked satiny lustre.

As before mentioned, polished surfaces of the larger, massive pieces of coralloidal aragonite from Dufton, Westmoreland, show a satiny lustre, which however is not nearly so marked as in the Alston calcite; also on the smaller branches are often numerous very fine crystals, regularly arranged at a small angle to the surface, these giving a fine satiny lustre to the surface of the branches. The name "satin spar" may, therefore, be applied to both calcite and aragonite, as well as to selenite.

In the examination of these fibrous and massive minerals, with the object of distinguishing and separating calcite and aragonite, the specific gravity and the microscopical characters of crushed fragments were most relied on. G. Rose[1] has shown that the specific gravity of a piece of fibrous aragonite taken as a whole may approach that of calcite; it is therefore necessary to take the specific gravity of the fine powder,[2] or of very small fragments, those having the most compact and homogeneous appearance being selected. If such a small fragment is placed with calcite (sp. gr. 2·72) and aragonite (sp. gr. 2·93) indices in methylene iodide, its specific gravity can be approximately judged by taking the times it floats after calcite and before aragonite, whilst the liquid increases in density owing to the evaporation of the benzene with which it is mixed. Fragments which have a specific gravity appreciably greater than that of calcite may then be considered to be aragonite, as the specific gravity of calcite could only be increased by impurities, which would be easily detected either under the microscope or by the action of acids. The same fragment that had been used for the specific gravity determination was

[1] *Abhandl. Akad. Berlin*, p. 10, 1856.

[2] This was done by H. C. Sorby (*Quart. Journ. Geol. Soc.*, XXXV. proc. 56, 1879), and was the test he mainly relied upon in distinguishing calcite and aragonite in shells, corals, &c.

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then finely crushed, and examined under a $\frac{1}{12}$ inch immersion in oil. If the mineral be calcite it is in nearly all cases easy to find small pieces showing the calcite cleavages, with the direction of extinction bisecting the cleavage angle, and in convergent light showing a uniaxial interference figure, usually towards the edge of the field of view. Aragonite, on the other hand, shows no cleavages, and indeed nothing very characteristic, unless a fragment be found which shows the biaxial interference figure near the centre of the field. The difference in the strength of double refraction of the two minerals does not seem to be great enough to be used as a characteristic test, as the fragments under examination are of such variable thickness; bright interference colours are, however, often seen in aragonite, but rarely in calcite.

By these methods it has been shown that many specimens labelled as massive and fibrous aragonite were really calcite. Amongst these were various *onyx* and *stalagmitic marbles;* thus confirming the recent work of G. P. Merrill,[1] who has shown by specific gravity determinations that the onyx marbles consist in nearly all cases of calcite. The *pisolite* of Carlsbad, Bohemia, as is well known, consists of aragonite; sometimes, however, the outer shell consists of radially fibrous calcite, which has all the appearance of having been produced by the paramorphic alteration of the aragonite; and as this shell increases in thickness, the whole spherule may become altered into calcite. The occurrence of calcite with aragonite in the banded sprudelstein of Carlsbad has been described by G. Rose;[2] he, however, considered the calcite to be original.

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[1] *Smithsonian Report* (*U. S. National Museum*) for 1893-4, 539, 1895. See this vol. p. 165.

[2] *Loc. cit.* p. 57.

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Zinckenite and Wolfsbergite (Chalcostibite) from Wolfsberg in the Harz; and the Zinckenite Group.

By L. J. Spencer, M.A., F.G.S.,
Assistant in the Mineral Department of the British Museum.

(Read November 17th, 1896.)

ALTHOUGH zinckenite and wolfsbergite are to be considered as isomorphous, it seems to be as rare a thing to find simple crystals of zinckenite as it is to find twinned crystals of wolfsbergite. In the following note simple and twinned crystals of the two minerals respectively are described.

For wolfsbergite twinning has not been previously recorded; and simple crystals of zinckenite have only been described by Kenngott,[1] although it is possible that much of the finely acicular zinckenite of various localities really consists of simple crystals, but, being unsuitable for measurement, cannot be definitely asserted to be such. The channelled hexagonal prisms of the Wolfsberg zinckenite were interpreted by G. Rose[2] as consisting of three interpenetrating crystals, as in aragonite; he gives a hypothetical figure of a simple crystal consisting of a rhombic prism, with an angle of 59°21′, and a macrodome. The crystals measured by Kenngott were acicular, and, adopting Rose's position, he gives the forms present as ∞O and $\infty O\breve{\infty}$, and the prism angle as 59°26′; he also mentions a large untwinned crystal with a single terminal face.

The specimen of wolfsbergite, on which a twin crystal has been noticed, shows several simple crystals, one of these measuring $3\frac{1}{2} \times 2\frac{1}{2} \times \frac{1}{2}$ cm. The twin crystal consists of two tabular individuals with the trace of their plane of junction parallel to the striations on the basal plane; the twin plane, which is also the plane of combination, is therefore a macrodome. On the broken end of the twin no discontinuity between the two individuals could be detected, so that it is not a case of accidental

[1] *Ber. Akad. Wien*, IX. 527, 1852.
[2] *Pogg. Ann.* VII. 91, 1826.

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juxtaposition. The angle between the normals to the two basal planes, as measured from wax impressions, is about 62°; for the twin plane to be (102)[1] the calculated angle is 62°37′.

The zinckenite specimen to be described had, on account of the habit of the crystals, been labelled as wolfsbergite, but analysis showed it to contain lead, antimony and sulphur, while copper and arsenic were absent. The blade-shaped crystals, which are small and somewhat indistinct, form a confused cellular aggregate on the flat surface of a matrix of stibnite and an indistinctly fibrous mineral containing lead, antimony and sulphur; this in turn rests on quartz, on the opposite surface of which are matted fibres closely resembling the feather-ore variety of jamesonite. On the first-mentioned surface are also a few small radiated groups of acicular crystals very like the usual zinckenite of Wolfsberg in appearance. The blade-shaped crystals are deeply striated parallel to their length, and show a large plane (c) with narrow planes (ε) at the edges; terminations are usually absent, being seen on only one crystal as a bright rounding. Attempts were made to measure six crystals, but, as they gave an almost continuous band of images, the results are not very satisfactory. On one crystal the four angles $c\varepsilon$ were determined as 30°, 31°, 29° and 30°. Another crystal gave $\varepsilon\varepsilon'$ as 57°, and others, for the same angle, various values between 55½° and 57½°. The mean value of $\varepsilon\varepsilon'$ may then be given as about 58°, which approaches to Rose's value of 59° 21′. On the second crystal a narrow plane at 90° from c was observed; and in some cases there seemed to be an imperfect cleavage parallel to this plane (*i.e.* a (100)). Placing the crystals in the position adopted by Dana[2] the forms present are then:—

$$c\ \{001\},\ a\ \{100\}^3,\ \varepsilon\ \{102\}$$

The first is new to zinckenite. To this short list of forms are to be added Rose's k {061}, and Luedecke's[4] b {010}.

The qualitative chemical composition, the angle of about 58°, and the absence of any distinct cleavage, make it probable that the above-described crystals are zinckenite, although it is not a matter of absolute certainty. There are several sulph-antimonites of lead, but unfortunately the

[1] The position of the crystals is that of Groth, *Tab. Uebers. Min.*, 3rd. Ed. 1889, p. 28.

[2] *System of Mineralogy*, 6th Ed. 1892, p. 112.

[3] This form a {100} has been recorded by Kenngott (*loc. cit.*), but has been previously overlooked.

[4] *Die Minerale des Harzes*, Berlin, 1896, p. 123.

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characters of some are imperfectly known; plagionite, meneghinite and geocronite have angles of 59°30′, 55°45′ and 60°16′ respectively, but possess cleavages, and in the case of plagionite the habit is totally distinct.

The only species that have been recorded from the Harz[1] are zinckenite, plagionite, jamesonite and boulangerite, all of which occur with wolfsbergite in the antimony mine, Jost-Christians-Zeche, near Wolfsberg.

The habit of these crystals of zinckenite being so similar to that of wolfsbergite, it would naturally follow that, in order to show the isomorphism between the two minerals, the crystals should be placed in similar positions, as has been done above; in which case they are flattened parallel to the basal plane, and elongated and striated parallel to the macro-axis. The new twin plane of wolfsbergite is then also the same as that given by Rose for zinckenite, namely ϵ (102). Beyond the usual presence or absence of twinning, the only important difference between the two minerals is the absence of any distinct cleavage in zinckenite. The somewhat abnormal form k {061} present on zinckenite is now seen to be also present on emplectite and wolfsbergite (guejarite)[2].

This position of the crystals has been adopted by Dana for zinckenite, sartorite and emplectite, and by Groth for sartorite, emplectite and wolfsbergite. In fact, for the purpose of showing the isomorphism of the group, the direction of elongation and striation of the zinckenite crystals has been made the macro-axis, the brachy-axis and the vertical axis by Dana, Goldschmidt[3] and Groth respectively; and a similar confusion has existed in the case of wolfsbergite. This has been due to the crystallography of these minerals being imperfectly known, and to the similarity of the angles in all three axial zones, as is shown in the following table of calculated angles—

	Zinckenite $PbS.Sb_2S_3$ (Rose).	Sartorite $PbS.As_2S_3$ (vom Rath)	Emplectite $Cu_2S.Bi_2S_3$ (Weisbach)	Wolfsbergite $Cu_2S.Sb_2S_3$ (Friedel for Guejarite)
001 : 102	29° 40½′	29° 51½′	*29° 56½′*	31° 18½′
001 : 101	*48 44*	48 57	*49 2½*	50 34½
001 : 011	*32 26*	31 45	*32 2*	32 31½
001 : 021	*51 48*	51 3½	51 22	51 54
001 : 061	75 18	*74 55½*	75 5	75 21
100 : 110	*29 8*	*28 19*	*28 30*	*27 40*

[1] O. Luedecke, *loc. cit.*; E. Schulze, *Lithia Hercynica*, Leipzig, 1895.

[2] The probable identity of wolfsbergite and guejarite was pointed out in a paper read before this Society on April 14th, 1896 (see this volume, p. x.).

[3] *Index der Krystallformen der Mineralien*, 1891, III. p. 331.

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The above angles are given in italics when the corresponding forms in the second column have not been observed on the particular mineral; (102) is the twin plane for wolfsbergite, but not an observed crystal face. The corresponding parameters are :—

	a		*b*		*c*
Zinckenite	0·5575	:	1	:	0·6353
Sartorite	0·5389	:	1	:	0·6188
Emplectite[1]	0·5480	:	1	:	0·6256
Wolfsbergite[2]	0·5242	:	1	:	0·6376

[1] Groth (*Tab. Uebers. Min.*, 3rd Edit.) calculates from Weisbach's measurements $a : b : c = 0{\cdot}5385 : 1 : 0{\cdot}6204$. The above are as given by Dana (*Min.*, 6th Edit.).

[2] Laspeyres gives for wolfsbergite—$a : b : c = 0{\cdot}52830 : 1 : 0{\cdot}62339$ (*Zeits. f. Kryst.* XIX. 428, 1891).

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The Crystallography of Plagionite: New Crystal Forms on Stephanite, Enargite and Anglesite.

By L. J. Spencer, M.A., F.G.S.,
Assistant in the Mineral Department of the British Museum.

[Read November 17th, 1896.]

Plagionite.

On the British Museum specimens of plagionite from Wolfsberg, in the Harz, all the well-established crystal forms previously recorded have been detected; these are:—[1]

$c\{001\}$	$a\{100\}$	$p\{114\}$	$e\{112\}$	$n\{111\}$
$x\{221\}$	$y\{331\}$	$s\{\bar{1}12\}$	$d\{041\}$	

The doubtful forms $i\{776\}$, $z\{\bar{7}.7.16\}$ and $\delta\{0.10.3\}$ of Luedecke[2] have not been confirmed. In addition to the above, the following new forms have been observed on the Wolfsberg crystals:—

$b\{010\}$[3]. A very small, bright plane on the edge between (221) and $(\bar{2}2\bar{1})$.

$f\{\bar{1}01\}$. A small bright plane, observed on two crystals.

$g\{\bar{2}01\}$. As a narrow bright plane, and also as a large plane rounded with a; on three crystals.

$m\{110\}$. Usually as a narrow plane on the edge between the two sets of pyramids; on one crystal with large faces; observed on three crystals.

$l\{223\}$. As a narrow bright plane, or as striæ; on six crystals.

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[1] The letters are those used by Miller (*Min.* 1852, p. 196) and by Goldschmidt (*Index der Krystallformen*, II. p. 479): the parametral plane is that of Goldschmidt, this being the direction of cleavage, and also giving rather simpler indices; other authors have taken e to be $\{111\}$.

[2] *Neues Jahrb. Min.* II. 112, 1883; *cf.* Goldschmidt, *loc. cit.* p. 480.

[3] Sandberger (*Ber. Akad. München*, XXIV. 241, 1894), mentions for crystals from Goldkronach, Bavaria, the form $\infty\breve{P}\infty$; this is, however, probaby a misprint for $\infty\breve{P}\infty$, which is a very common form on plagionite; or, again, d might easily be mistaken for (010) on mere inspection of the crystals.

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$h\{\bar{2}23\}$. As a narrow bright plane, or more often as striæ; on one crystal as a large face in the zone [221, $\bar{2}01$]; observed on six crystals.

$t\{\bar{4}45\}$. As a narrow bright plane, or as striæ; on three crystals.

$k\{\bar{1}11\}$. As a narrow bright plane, or as striæ; on three crystals.

Also, doubtful:—

$\{\bar{7}03\}$. As a narrow rounded plane, on one crystal measured to c as 73°54′, calculated 73°43′.

$\{\bar{7}02\}$. As a narrow rounded plane, and as striæ; on two crystals; measured to c as 83°49′, 84¼°; calculated 84°45½′.

$\{\bar{7}01\}$. Due to roundings and striations on a; several measurements between 96°8′ and 96°50′; calculated, $c : (\bar{7}01) = 96°12'$, $c : (\bar{1}5.0.2) = 96°57\frac{1}{2}'$.

{4.4.11}. As a narrow bright plane; on two crystals; measured to c as 19°24′, 20°6′; calculated 19°57′ [$c : (225) = 21°36'$].

$\{\bar{1}14\}$. Several bad measurements from striæ at about this position; calculated, $c : (\bar{1}14) = 15°54'$.

$\{\bar{2}25\}$. Only as striæ; measured to c, 24°17′, 24°37′, 24¾°, 25°34′, 26°26½′; on four crystals; calculated 25°18′. This is near to Luedecke's $z\{\bar{7}.7.16\}$ or $\{\bar{4}49\}$.

The measurements establishing the more certain forms are:—

	Observed Mean.	Limits.	No. of Faces.	Calculated (Luedecke).
xb	51° 18′	—	1	51° 26½′
ab	90 0	—	1	90 0
cf	42 8	41° 54′ — 42° 22½′	2	42 26
cg	68 43	68 6 — 69 7	6	68 34½
cm	78 21	77½ — 79 16	6	78 26½
am	47 44	47 39½ — 47 46	3	47 16
cl	32 32	31 51 — 33 37	6	32 3½
ch	40 3	38 0 — 42 46	9	40 6
ct	46 55	46 20 — 47 40	4	46 18
ck	54 43	52 10 — 56 15	5	54 6½

The striated pyramidal zones usually give a continuous band of reflected images. Numerous measurements from the brighter parts of these bands were rejected, although in some cases they led to definite indices, except when there was a repetition of the same angle several times, or when the reflection was seen to be from a definite face and not from striæ. The forms *e n x* in the zone of negative pyramids occur as definite faces on nearly all the crystals, but the faces in the zone of

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positive pyramids are very badly defined; *s*, for example, being rarely as a definite face.

As mentioned by Luedecke[1], there is a frequent oscillation between the basal plane and the pyramids, and, as a result of this, the two faces of the form {001} are rarely parallel. This, in connection with the deep striations, renders the measurements very unsatisfactory—so much so that, although 18 crystals were measured, no attempt has been made to improve on the parameters deduced by Luedecke, which are based on only three measured angles. However, the angle for *am* given above may be taken as fairly accurate, as well as the following angle for *ac*; but, owing to the wide variation in *cn*, not much reliance can be placed on this angle.[2]

	L. J. Spencer.			G. Rose.	Luedecke.	
	Observed.	Limits.	No. of Readings.	Observed.	Observed.	Calculated.
ac	72° 28½′	72° 3′ — 72° 52′	9	72° 28′	72° 40½′	—
cn	41 18	39 44 — 42 45	31	41 8	41 7	41° 26½′

The only determination which has been made of the specific gravity of plagionite is that made in 1831 by Zincken, who obtained the value 5·4. The following determinations have been made on Wolfsberg crystals, but they can be only considered approximate owing to the difficulty of separating pure material without destroying the rare crystals.

A group of crystals, with a little "tinder ore" attached, weighing 2·6642 grms., gave sp. gr. = 5·57. Crystal fragments and isolated crystals, with a somewhat drusy surface, weighing 0·667 grms., gave sp. gr. = 5·47.

Six isolated crystals, some with a drusy surface, weighing 0·4640 grm., gave sp. gr. = 5·55.

The mean of these determinations, about 5·5, is thus a little higher than that given by Zincken.

The occurrence of plagionite in the stibnite deposits of Arnsberg, Westphalia, has been recorded by Sandberger,[3] and in his note he mentions that the specimens show some needles having the appearance

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[1] *Loc. cit.*

[2] These angles, $ac = 72°28\frac{1}{2}'$, $am = 47°44'$, and $cn = 41°18'$, give the parameters $a : b : c = 1·1538 : 1 : 0·8508$.

[3] *Neues Jahrb. Min.* II. 94, 1883. Compare *Ber. Akad. München*, XXIV. 241, 1894, where different symbols for the faces are given.

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of federerz ("plumosite"), which he supposes to be Pisani's "heteromorphite." In Pisani's paper,[1] however, there is no mention of needle-shaped crystals,[2] and the mineral he dealt with was without doubt plagionite, as is to be seen from his minute description of the crystals, which are given as being possibly monosymmetric, and are referred to "heteromorphite" as distinct from jamesonite. He distinctly states, however, that the mineral is not plagionite; but this statement was probably influenced by the results of his analyses and by the habit of the crystals. This habit of the crystals, although it is fairly common on the Wolfsberg plagionite, has only been mentioned by Kenngott.[3] Here the pyramid $n\{111\}$ is elongated in the direction of the zone axis $[111,1\bar{1}1]$ and c and a are equally developed, or one is developed to the exclusion of the other.[4]

The British Museum specimens from Arnsberg agree completely with Pisani's description, and the curved, indistinct crystals were found on measurement to be plagionite. One of the three crystals measured showed the forms *c a p e n*.

According to the analysis given by Pisani, however, the composition ($7PbS.4Sb_2S_3$) of the material is much nearer to jamesonite ($2PbS.Sb_2S_3$) than to plagionite ($5PbS.4Sb_2S_3$). It would have been interesting to have had the details of the four analyses (of which the one given is the mean of three) which were made on the crystalline and massive mineral, especially as the various analyses of the Wolfsberg plagionite show very little variation amongst themselves. For these reasons the Arnsberg mineral has come to be mentioned in the text-books under both jamesonite and plagionite. It is to be noted, however, that it is correctly given as plagionite by Kaiser;[5] and in Groth's General-Register to *Zeits. für Kryst.*, Vols. 1—10, the reference here being to the abstract of Pisani's paper.

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[1] *Comptes Rendus*, LXXXIII. 747, 1876.

[2] The abstract of Pisani's paper in the *Neues Jahrb. Min.* 300, 1877, mentions needle-shaped crystals, and it is probably hence that the mistake arose. Koort (*Beitr. z. Kenntn. des Antimonglanzes, Inaug.-Diss.*, Berlin (Freiberg i. B.), 1884, p. 10), mentions acicular and capillary stibnite from this locality.

[3] *Ber. Akad. Wien*, XV. 236, 1855: figs. 5 and 6, plate I.

[4] The figure of a plagionite crystal given in Dana's *Mineralogy*, editions 2 to 5, more or less illustrates this case.

[5] *Zeits. für Kryst.* XXVII. 50, 1896, footnote 2.

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Stephanite.

To the new forms determined by Prof. Miers[1] on the British Museum specimens the following may be added.

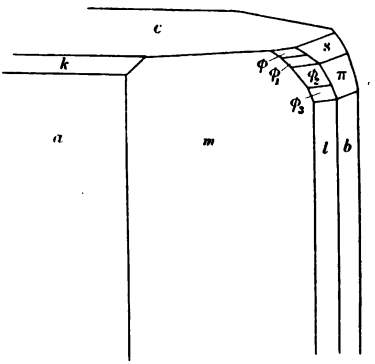
A small bright crystal of stephanite from Chili showed the new forms {551} and {10.10.13} as narrow faces in the zone [001, 110].

	Measured.	Calculated.
c : (551)	81° 23′	81° 10′
c : (10.10.13)	44 36	44 42

The crystal was twinned on $\pi(130)$, and showed twin lamellæ parallel to $m(110)$; the other forms[2] present were $c\ M\ h\ l\ P\ p_3\ r_1\ m\ k\ d\ b$.

Enargite.[3]

A well-developed, isolated, but singly-terminated, prismatic crystal of enargite from Peru (probably Morococha), with large $a\ m\ c$, narrow $b\ l\ h\ d\ k$, and small s, showed the new forms $\pi\{031\}$, $\phi\{132\}$, $\phi_1\{394\}$, $\phi_2\{131\}$ and



$\phi_3\{892\}$. The two quoins of the crystal formed by the basal plane and the prism m (namely by (001) (110) ($\bar{1}10$) and (001) ($1\bar{1}0$) ($\bar{1}\bar{1}0$)) are rounded by these small, rather rough and curved, but bright faces, which lie in the zones $[cb]$ and $[cl]$. The position of $\pi\{031\}$ is fixed by—

	Measured.	Calculated.
$c\pi$ (001) : (031) ..	68½°	68° 8⅓′

[1] *Zeits. für Kryst.* XVIII. 68, 1891.

[2] The letters for the forms are those used by Dana (*System of Mineralogy*, 6th Ed.); and the above angles are calculated from the parameters he gives.

[3] *cf. Min. Mag.* XI. 69, 1895.

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The other faces were then determined by the zones $[m\phi_3\pi\phi_1']$, $[m\phi_3\phi']$, $[m\phi s k']$ and $[a\phi_3 s]$, and confirmed by the angular measurements, which, however, in some cases depended on maximum illumination. Another similar crystal, from the same locality, showed the forms *c k μ u a r m l b o*, together with indefinite rounded planes in the zone [*cl*].

ANGLESITE.

A specimen, of unknown locality, recently presented to the Museum by Mr. H. J. Gardiner, F.G.S., shows numerous well-developed crystals of anglesite on a matrix of pyrites, the latter being coated with a thin green layer of sulphate of iron. The crystals are of prismatic habit (in the direction of the zone axis [100]), and are terminated, often at both ends, by an acute pyramid; the only forms present being *o*{011} and the new form *l*{255}. The faces are striated parallel to the intersections of the dome and the pyramid; the domal faces are much smoother and brighter than the pyramidal faces. The following measurements were obtained from one crystal:—

		Measured.	Calculated (Kokscharov).
$011 : 0\bar{1}1$	...	104° 18′	104° 24½′
011 : 255	...	21 51 21 57 22 0	21 55⅔

An occurrence of Prehnite in Wales.

By W. Jerome Harrison, Junr.

[Read November 17th, 1896.]

THE little land-locked harbour of Pwllheli in Caernarvonshire owes its existence to a boss of igneous rock, which forms a natural breakwater, and which is known in Wales as the "Gimlet Rock."

The large quarries afford excellent exposures of the rock, which is worked into "setts" and used largely for paving purposes in the large towns of Lancashire, etc. It is a coarse ophitic dolerite, in which the augite is a very conspicuous mineral. The rock is traversed by many segregation veins, and is much jointed. The faces of the larger joint-planes are covered with crystals of quartz, calcite, a little natrolite, brookite and prehnite. But the three last-named minerals are of rare occurrence, and are always associated with quartz.

The *prehnite* crystals I found at the "Gimlet" last July.

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On the Micas of the Three Rock Mountain, Co. Dublin.

By Professor J. P. O'Reilly, Roy. Coll. of Science, Dublin.

[Read April 14th, 1896.]

THE micas presented by the granites of the Co. Dublin have been analysed by Haughton, and determined by him to be margarodites and lepidomelanes (see *Proc. Roy. Irish Ac.* Vol. VI. 1855, pp. 176-79, and *Quart. Journ. Geol. Soc.* Vol. XV. 1859, p. 129). In this latter paper he says:—"In my first paper on the Granites of Leinster (*Quart. Journ. Geol. Soc.* Vol. XII. 1856, p. 171), I have mentioned the black mica which is found accompanying the white margarodite of the Leinster granite in small flakes, and noticed the curious fact that these flakes are sometimes physically embedded in the plates of white mica without injuring their fissility or lustre, but always effecting a reduction of about 20° in the angle between the optic axes of the latter."

In the first mentioned paper ("On the Chemical Composition and Optical Properties of the Mica of the Dublin, Wicklow and Carlow Granites") he thus describes the first specimen examined:—"No. 1. Mica from the Three Rock Mountain, Co. Dublin; gray, transparent, containing specks or flakes of a bronze-coloured or black mica."

He further adds, when speaking of the deviation of this mica from the formula found to result from his analysis:—"The mica which deviates the most from this formula is the mica of the Three Rock Mountain, and this deviation may possibly be due to the presence of grains of black mica, which also occurs in the mass of the granite, and of which I was unable to obtain a sufficient quantity for chemical or optical examination; the quantity of protoxides in the Three Rock Mica is somewhat in excess of that required by the formula."

The author of the present paper having frequently had occasion to pass by the road which leads over the east end of the Three Rock Mountain into Glencullen, had his attention drawn to the micas which show themselves in the stones and boulders forming the walls and fences of the fields along the road. These micas are relatively large, very pearly in lustre, and almost without exception, when large, show a zonal

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structure due to the linear arrangement of the bronze and brown specks or flakes, and very generally the central part of the mica is filled with these same flakes or patches, but with larger dimensions. Struck by this character, and desirous of examining the relations of the constituent parts, I collected from time to time a large number of these micas from the stones and boulders, and also from a portion of a mica band or vein which occurs on the north side of the mountain, in the midst of the stone quarries which extend over this face.

I proposed to mechanically separate the white or colourless portion of the micas from the bronze or black specks, and to have each part thus separated chemically examined. The task of separation was undertaken by Miss Mary Robertson, M.A., then engaged in research work in the laboratory of the Royal College of Science, under the direction of Professor Hartley; and after some weeks of tedious and careful picking, enough of the separated materials was obtained to allow of the proposed analysis being undertaken. The following is the Report which she furnished as to the result:—

"Chemical Laboratory,

"Roy. Coll. of Sci., Dublin, May 4th, 1889

"Sir,—With regard to the sample of mica submitted to me for analysis, I have made the following observations. The mica is essentially white or colourless, but contains black specks, generally occurring in the centre of the crystal, *i.e.* in hexagonal shape, and leaving the centre comparatively clear. In cleaving the mica, black stains were often visible, coinciding in shape with a speck underneath, The specks usually broke away with comparative ease from the surrounding white portion. One black portion was found of rather larger size than usual, which had the hexagonal shape of the large crystals.

"In preparing for the analysis, the crystals were split, and the black specks separated and collected under the microscope. The white portion was also carefully collected, and freed from any black specks. Separate analyses were made of the two substances so obtained.

"The quantities available were so very small that only a quantitative analysis could be made; but in the course of this analysis search was made for substances which might occur.

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"I find that the white portion contains as follows:—

Weight taken for analysis—for bases ...	1·1056 grm.
,, ,, ,, ,, for alkalies ...	0·6075 ,,
Loss by ignition	4·710 per cent.
SiO_2	39·414 ,,
(Cuprous Oxide) Cu_2O ...	3·654 ,,
Al_2O_3	33·738 ,,
Fe_2O_3	1·418 ,,
MnO	1·244 ,,
MgO	1·344 ,,
CaO	0·955 ,,
Li_2O	0·642 ,,
Na_2O	2·675 ,,
K_2O	9·430 ,,
Total	99·224 ,,

"An analysis of the black mica was also made, but copper and iron seemed to be present in varying quantities, so that different portions gave varying results.

"It was then found that on treating the dark specks with hydrochloric acid, the colouring matter dissolved, leaving a residue of white mica. A portion so treated gave on analysis:—

Residue insoluble in HCl	45·14 per cent.
Ferric Oxide, containing traces of Mn ...	45·14 ,,
Cuprous Oxide	9·78 ,,
(The amount taken for analysis having been 0·0101 grm.)	100·06 ,,

"The copper was very carefully estimated in another portion of the dark substance, and found to amount to 22·5 per cent. Cu_2O; the alkalies in the same portion were 13·70 per cent., estimated as soda.

"The iron was estimated in another portion of the dark substance, and found to amount to 25·35 per cent. of Fe_2O_3. Hence the copper and iron appear to occur in varying proportions in the dark substance.

"A portion of the loss by ignition is due to *hydrofluoric acid*, traces of which were found; none was observed in the substance after ignition, though carefully tested for.

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"A portion of the original substance, containing both the white and the black bodies, was used to estimate the combined water, and gave the following result:—

Water driven off at 100°C.	0·2506 per cent.
,, ,, ,, between 100° and 240° ...	0·1058 ,,
Thus showing that the loss on heating to 240°C. was	0·3564 ,,

"(Signed) MARY W. ROBERTSON, M.A."

Comparing this analysis with that of Dr. Haughton already referred to (given in *R. Irish Ac. Proc.* Vol. VI. 1855, p. 177), and which is mentioned as "No. 1, Mica from the Three Rock Mountain, Co. Dublin; gray transparent, containing specks or flakes of a bronze coloured or black mica," the following differences appear—

	Miss Robertson's.	Dr. Haughton's.
SiO_2 ...	39·414 per cent.	43·47 per cent.
Al_2O_3 ...	33·738 ...	31·42
Fe_2O_3 ...	1·418 ...	4·79
CaO ...	0·955 ...	1·38
MnO ...	1·244 ..	——
MgO ...	1·344 ...	1·13
K_2O ...	9·430 ...	10·71
Na_2O ...	2·675 ...	1·44
Li_2O ...	0·642 ...	——
Cu_2O ...	3·654 ...	——
Loss by ignition	4·710 ...	5·43
	99·224	99·77

It may be remarked that the amount of SiO_2 in the analysis of Miss Robertson is lower by 4·056 per cent. than that of Haughton, and lower than any example of muscovite cited by Dana in the edition of 1892, p. 617, wherein the extreme values for SiO_2 are 49·34 per cent. and 43·67 per cent. Assuming Miss Robertson's determination of the silica to be quite correct, the amount found, 39·414, would correspond rather with a biotite, and in this respect would harmonise with Haughton's remark as to the reduction of the angle of the axes. The other values correspond fairly well: what however is remarkable is the high value for the

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cuprous oxide, Cu_2O = 3·654 per cent. The element copper is not unknown, as a constituent of the micas, since in the list given by Dana it occurs in two cases, one amongst the analyses of damourites, &c., and the other in the analysis No. 61 of "*Œllacherite*" from the Pfitsch-thal with an amount of CuO = 0·31. In both cases the copper is given as cupric oxide. However, there is evidence that it may occur in relatively large quantities in certain minerals of the chloritic group, as is shown by Sterry Hunt, in his *Mineral Physiology*, 1886, p. 357, where he describes, under the name of "Venerite," a mineral containing, according to the analysis of Hawes, 17·58 per cent. of CuO, and referred to the chlorites.

Assuming for the moment that the copper found in the Three Rock Mountain mica by Miss Robertson exists in combination with SiO_2, it is presumable that such a silicate of copper should to some extent influence the colour of the white mica, since no colourless silicate of copper so far is known. Now the samples analysed by Haughton as well as the material used by Miss Robertson seem to have been equally devoid of colour (macroscopically examined), and are described as being *gray and transparent.*

Under the microscope, however, most of these transparent gray and colourless muscovites of the locality mentioned show black specks, more or less minute, and for the most part round like blots of ink, or exceptionally somewhat hexagonal.

These minute specks may be tenorite (CuO), and the fact that, according to Jenzsch, the artificially prepared tenorite is rhombic and possesses a perfect basal cleavage would favour the presumption. They might equally be *melaconite*, which also presents itself in a scaly form, and occurs interlaminated with chlorite. The *melaconite* of Vesuvius is stated by Dana to be frequently hexagonal, and sometimes triangular in shape. The different forms presented by the black specks would best agree with this interpretation, and with other characteristics of the muscovites now considered.

It must be remembered that the specimens examined by Miss Robertson were from different points of the mountain, and that some particular point, say the mica vein mentioned, may really have furnished the copper samples.

The muscovites of the Three Rock Mountain and vicinity present other characteristics which connect themselves with those already considered, and come out when thin cleavage plates are examined under the microscope. For the most part the plates show a zonal structure, the zones being mainly composed of irregularly bounded brown patches, sometimes showing

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a rough hexagonal form with rounded corners and only rarely clearly defined hexagonal or triangular forms: these patches are evidently very thin and intermixed with the plates of muscovite, but so that the patches cover one the other quite irregularly as regards outline, giving rise thus to composite patches of quite jagged contour. With these brown patches and lying between them occur black specks and spots smaller in extent, evidently connected with the brown ones, generally round, sometimes fringed with a less black or very dark gray mineral; lastly, here and there in the majority of plates examined from the Three Rocks Mountain, but sparingly and quite microscopically appear what may be designated "blue micas" (?), which contrast markedly with the brown and black spots by the perfect geometrical regularity of their forms.

The largest individual specimen examined did not exceed 0·5 mm. in breadth, and generally they are quite microscopic but very distinct (see Pl. iv.). The predominant forms are seemingly perfect equilateral triangles, hexagons resulting from the truncation of the angles of such triangles, perfect hexagons and occasionally forms of rectangular shape or of an L shape pointing to the existence of rhombic cleavages in the mineral. Their colour presents all the shades of blue from faintly purple to most intense blue, such as Prussian blue or the cobalt blues of pottery ware; exceptionally a faint but distinct rose tint is met with, and more frequently the blue is so intense as to appear black. The contours are always strictly geometrical, and the angles formed by the sides perfectly sharp and well defined. The plates are evidently very thin, and may be seen, even in thinly cleaved micas, covering one another; they are translucent, and under polarised light they behave isotropically.

Apart from the colour, their form and their conditions of relation to the containing mica would favour the opinion of their being micas, but the colour, or rather colours, presented by them would lead to their being referred to one or other of the minerals characterised by blue colours. As regards the black triangular plates, there is every reason for connecting them with the black spots or patches already referred to, and consequently considering them as melaconite; on the other hand, it is reasonable to see in the blue triangular plates always present with the black ones a variety or an altered form of the same mineral, such as for instance a chrysocolla ($CuO.\ SiO_2+2aq$) altered from the melaconite or tenorite. This presumption would be in accordance with the translucence and low refrangibility of the plates, the forms and the analysis, but can only be taken as a presumption until further examination of them has fixed their

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true nature; as, however, there are other minerals characterised by a blue colour and allied to the micas, it is necessary to examine whether one or other of them may not better correspond to the characters presented by the mineral in question. Dana mentions amongst such minerals Diphanite and Vaalite.

Considering, however, that *iolite* has been determined by Dr. Joly to exist in the granites of the neighbouring valley of Glencullen, distant from the Three Rock Mountain only about 1½ mile (see *Sc. Proc. Roy. Dub. Soc.* 1886, Vol. V. part 2), and that the colour of the plates corresponds well in a number of cases with that of iolite (Berlin blue in different intensities), the question arises Do the other characteristics presented by the plates correspond to those shown by iolite? Certain of the angles of the apparently equilateral triangles were measured, and while one gave 60°, another more carefully handled gave 61°18′. Now this would rather point to a rhombic mineral, having a prism angle approaching 120°, as in the case of iolite, and $\infty P\breve{\infty}$ cleavage as presented by this mineral (see fig. c, Pl. VI.). Lastly, if there be supposed a composition plane parallel to ∞P, the triangular form presented by the mineral becomes intelligible (see fig. g, Pl. VI.), giving for the angle at the summit 60°50′, and for the two basal angles 59°35′. This twinning being assumed, an explanation is afforded of the little *notch* presented so frequently by the plates on one of the sides of the triangle, as shown in one of the figures (fig. a of Pl. VI.). Lastly, the fig. c same plate points to alterations along a section taken as $\infty P\breve{\infty}$, and so far confirms the rhombic character of the mineral. From the co-existence of the different characters it may reasonably be assumed that the mineral in question is "iolite" in a more or less altered state, and then, according to Dana, tending to the "division of the prism into plates parallel to the base." The largest of these plates met with was only 0·5 mm. broad, and is represented on fig. 2, Pl. IV. The notch referred to is here also observable, as also on many of the black triangles and hexagonal forms shown on Pl. IV., and seems to connect them so far with the blue plates.

The brown patches so characteristic of the micas, as indeed of many other muscovites, were studied by G. Rose (see *Monats-ber. der Acad. Berlin*, 1869, p. 339); he noted that generally the white colourless mica surrounds the brown ones. He concluded that the black to brown tablets were ironglance, while Dana and Brush considered the black plates to be magnetic iron, the red ironglance, and the yellow hydrated oxide (see Zirkel, *Elemente d. Mineralogie, von* C. F. Naumann, 1881, p. 571).

The black patches present themselves under two forms, or rather three:

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regular triangles or hexagonal forms, perfectly opaque; blebs or blots equally opaque, but irregular in form, and frequently "dusted" or sprinkled, as it were, between the plates of mica; and lastly, round patches, grayish rather than black, the tint graduating in intensity from the centre to the circumference, as indicated on Pl. VII. These are remarkable in that the centre of figure is frequently marked by the presence of a microlite, perfectly transparent and colourless as a rule; seemingly of the same nature as the many similar microlites which show themselves in most of the mica plates examined. What the exact relation may be that seems to exist between the central microlite and the black patch has not been ascertained so far.

In all the micas examined, the presence of the rod-like voids which have been frequently noticed by most observers was recognised and in certain cases they appear filled with a product of decomposition having an earthy appearance of a yellowish colour.

The brown patches generally found in the centre of the mica plate, and having seemingly no relation of arrangement with the sides of the crystal, are frequently surrounded by a zone of smaller brown patches and brownish crystallites, generally forming a line parallel to the sides of the prism, and therefore having a rhombic or hexagonal outline. This zonal structure is markedly present in the micas from the east side of the Three Rock Mountain. Its general character is indicated by the enlarged drawing shown on Plate V., on which is also indicated the remarkable banded structure observable in the mica plate when held in a plane of about 45° with the line of vision, and then examined with a lens. These bands generally lie outside the zone of small brownish patches, and but rarely extend to the margin of the plate. They would seem to be connected with stages of growth of the mica crystal. The small brownish patches already referred to seem at first sight to have no relation of direction with the principal lines of the mica plate; but more carefully examined, they frequently show themselves as lying nearly perpendicular to the direction of the zone, just as crystals lining a cavity of a rock stand out more or less normally from the sides.

Amongst these small brownish patches occur frequently small prismatic crystals, quite regular in form, and presenting angles which would point to rhombic or monoclinic forms. Certain of them are markedly dichroic, and show strong absorption—so much so indeed that sections which are nearly invisible when in one section-plane of the nicol, become nearly black or very intense brown when brought into the other. A certain number of them show reddish-brown in one plane of the nicol and

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greenish in the other, tints characteristic of hypersthene, but the absorptions are quite equal to those presented by the hornblende series. No indication, however, of a hornblende cleavage was remarked. These crystals are quite microscopic, but from the sharpness of the outlines the angles are measurable. The colour is generally somewhat redder and the lustre greater than in the case of the brown mica plates, while the refrangibility is evidently great.

While occupied with these micas and continuing to collect from the eastern side of the Three Rock Mountain only, circumstances led me to look for large sized micas on the western side, at the point known as Barnaculla. Here a vein of very micaceous granite was shown me evidently having undergone fissuring and pressure, the mica plates which it shows presenting a certain parallelism of direction and crumpling, the rock possessing a gneissose character. These micas are often two cm. in length and show regular forms, that is, are more or less hexagonal or rhombic in outline. They proved to be somewhat harder than the micas of the east side, cleaving with more resistance and showing on the cleaved faces undulations, seemingly the consequence of pressure. The examination of the cleaved plates of these micas showed differences of constitution, as regards the micas of the east side of the mountain, very interesting, and so general throughout as to be in all probability characteristic of a large extent of rock. One of the peculiarities presented by them is a certain crumpling or fluting along the margin of the cleaved plate, see Pl. V., as if the crystal had been subjected to pressure and strain parallel to the directions of the sides of the crystal. This crumpling extends to a certain distance into the field of the plate, and is associated, as in the case of the micas of the east side, with the zonal line structure already referred to, as also with a similar zonal arrangement of small mica specks or flakes, with however the marked distinction that while in the micas of the east side examined no green patches or flakes showed themselves, they seem to dominate the brown patches in the cleaved plates from Barnaculla and to characterise them very distinctly. These green patches present, on the whole, outlines less jagged than the brown ones of the east side: the forms are often regular, and somewhat hexagonal in shape. The colour is generally that of a green olive oil, drops of which the micas frequently resemble; the lustre is weaker than that of muscovite, and corresponds to that of certain biotites and the generality of chlorites. The figures (*a*) and (*b*) of Pl. vii. give illustrations of their appearance under the microscope. In (*a*) the mineral is penetrated with minute grayish and blackish granules,

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while in (*b*) the granules are larger, seemingly of the same nature as the mineral itself, and show stumpy prismatic forms not sufficiently regular in any of the specimens examined to allow of trustworthy measurements being made. With this granular structure is intimately allied the development of reticulated and brush structures, made up of opaque brown lines or needles and intersecting at angles seemingly in relation with the crystal forms of the mica. Every gradation of reticulated structure may be observed, from the merest outline to the complete filling up of the crystal space. Examples are shown on Pls. VI. and VII. Such reticulations are characteristic of rutile, and are well-known occurrences in quartz and also in biotites. When the network shows forms with an angle of about 60°, as occurs in the specimens examined, the structure represents the "sagenite" of Saussure. The examples presented by Pl. VII. (*c*) and (*d*), correspond well with that form; but in nearly every plate of green mica examined, there were present these brown reticulations in more or less advanced stages. They are referred to by Zirkel in his article on biotite, in his last edition of his *Lehrbuch d. Petrographie*, Vol. I. pp. 330-333 (1893). He examines very fully the question as to whether these reticulations are to be considered of primary or of secondary formation, and cites the different authorities for and against. His conclusion is that in reality the apparently contradictory statements of the observers cited may be reconciled by admitting that in biotites rutile may exist as of primary formation. In those of Barnaculla the occurrences are so frequent and general that every degree of development of formation may be observed, and as green micas exist therein which show no rutile needles, it is reasonable to assume that the reticulations are of secondary formation This is to a certain extent borne out by the fact that in certain plates a last stage of decomposition may be seen, whereby the needles seem to become earthy, to lose distinctness of outline, and assume forms markedly dendritic, as shown in Plate vii. Judging from the colour and other characters presented by this last stage of decomposition, it may be assumed that it represents the titanomorphite state.

None of the analyses published of Irish micas show the presence of titanic acid, although in the series given by Dana for muscovite and for biotite TiO_2 is frequently indicated as present; in the case of the muscovites only in small quantities (to 1·52 per cent.), but in that of biotite more frequently and in more notable quantities (up to 4·73 per cent.). In the rocks of Bray Head, however, it has been shown to exist, and a more extended and careful series of analyses would in all probability show its presence in the micas of the Dublin granites, more especially in

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the biotites, taking the "sagenite" reticulations herein described as indications of such presence.

Note on the presence of copper in the mica of Glencullen, Co. Wicklow (referred to in Professor O'Reilly's paper "On the Micas of the Three Rock Mountain").

(Extract of letter from Mr. Charles Darling, Assoc.R.C.S. Dublin, Demonstrator in Chemistry at the Royal Military College, Woolwich, 3rd March, 1899.)

"I have much pleasure in forwarding you the figures of my analysis of the Glencullen mica, taken from my college note book:—

SiO_2	...	42·99 per cent.
Cu_2O	...	0·10 ,,
MnO	...	0·06 ,,
FeO	...	2·69 ,,
Al_2O_3	...	34·44 ,,
CaO	...	0·54 ,,
MgO	...	0·77 ,,
K_2O	...	13·27 ,,
Na_2O	...	trace ,,
H_2O	...	5·05 ,,
		99·91 ,,

"The cuprous oxide, as you will observe, is much less in quantity than was found to be the case with the Three Rock Micas. I believe in the latter case the Cu_2O crystals were distinctly visible, and were traced out under the microscope by Miss Robertson. In the sample provided me by Professor Hartley no such operation was possible; but there can be no possible doubt as to the presence of the copper in the proportion stated, as I made the estimation three times with the same result. The quantity being small, a colorimetric method was adopted, the *modus operandi* being as follows:—

"The mica was fused with mixed carbonates of soda and potash until decomposed; then treated with strong HCl and taken to dryness to render the SiO_2 insoluble; treated again with HCl and filtered. The filtrate was then saturated with H_2S, the copper precipitate filtered off, and after washing with H_2S water, was dissolved in boiling dilute HNO_3. Excess of ammonia was now added, so as to produce the blue colour, and the solution transferred to one of two graduated tubes having the same bore.

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The second tube contained a solution made by dissolving a known quantity of metallic copper in HNO^3 and adding excess of ammonia. One or the other was then diluted until the tints were matched."

Note on Miss Robertson's Analysis of the Three Rock Mountain Mica.

By Professor W. N. HARTLEY, F.R.S., Royal College of Science, Dublin.

[Communicated April 26th, 1897.]

IN the analysis of mica executed by Miss Robertson for Professor O'Reilly in my laboratory, and under my guidance and advice, it will be observed that the copper is stated to be present as cuprous oxide Cu_2O. There was no evidence whatever of its being cupric oxide CuO. That the whole of the copper was present as Cu_2O in the sample analysed was shown by the following tests, which were made by me at the time:—

1. The microscopic examination of the mica showed the presence of no black, green or blue particles, such as would be characteristic of a cupric compound. 2. The colour of the mica, which was reddish, was seen to be caused by crystalline spangles of a bright red colour, many of them more or less of a ruby or garnet tint. 3. These coloured particles dissolved easily in warm hydrochloric acid, leaving the mica clear and colourless. 4. The hydrochloric acid solution was brown, and on dilution with water became turbid from a precipitation of what can only have been white cuprous chloride. 5. The particles of mica which were coloured gave a red glass by fusion with borax. This would not have been the case with a cupric compound.

There being no evidence whatever of the copper being in two different states of oxidation, the analytical results were calculated upon the evidence afforded by the above tests, for which the quantity of material available was very small.

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On Nemalite from Afghánistán.

By F. R. Mallet, late Superintendent, Geological Survey of India.

(Read February 2nd, 1897.)

IN 1887, when I was in charge of the Indian Geological Survey laboratory, a specimen of a mineral recently discovered in Afghánistán was sent to Calcutta by the British Agent at Kábul, with a request for information as to its nature and value. It proved to be nemalite, and a quantitative analysis of it, which was subsequently made by Mr. T. Blyth, is published in the fourth part of *A Manual of the Geology of India*, p. 161. As it seemed possible that the mineral might be capable of some useful application if plentiful, and it was in any case of mineralogical interest, a request was made to the Agent for further information about it, including the locality where it was found, and for additional specimens. The information asked for did not appear to be procurable, but a box full of the mineral, containing, as far as I remember, more than half a hundredweight of the substance, was sent to the Geological Museum. When retiring from India some years ago, amongst a few specimens of Indian minerals which, with the permission of the then Director of the Survey, Dr. King, I brought to England, in the hope of being able to examine them at some future time, was a picked sample of the nemalite in question. It is, however, only recently that circumstances have allowed of my making a commencement of such work, by an examination of the mineral I have alluded to.

The specimens sent were all very similar to each other in outward appearance, but differed more or less in the amount of alteration they had undergone, which could be roughly judged by eye through variations in colour and translucency. The sample I selected was one of those which appeared to have undergone the least change.

It consists of a mass of straight, very fine, highly flexible and elastic, easily separable fibres eight inches long, which seem clearly to have formed part of a vein. Some particles of serpentine, adherent to one end of the specimen, indicate that the rock in which brucite has generally

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been found elsewhere is the probable matrix in Afghánistán also. The ends of the specimen show that the fibres were not perpendicular to the walls of the vein, as is more usually the case with fibrous minerals, but made an angle with the walls of about 20 (or 160) degrees. Whether this was due to a local twist in the direction of the walls at the spot from which the specimen was taken, or is common to the whole vein, I do not know.[1] Both ends of the specimen show very obvious signs of chemical alteration, but the central part, for about five inches, is, to all outward appearance, both to the naked eye and under the microscope, perfectly fresh; and that it has not undergone any considerable change is shown by the absence of both carbonic acid and ferric oxide. The sample used for examination was of course taken from this portion.

Viewed transversely to the fibres the colour by reflected light is sea-green, with a silky lustre; by transmitted light, pale to dark sea-green, according to the thickness of the specimen. Viewed by transmitted light parallel to the direction of the fibres, the colour is very similar. In a specimen an inch long, the colour is sufficiently intensified to approach a pale emerald-green. The colour of the mineral is doubtless due, mainly at least, to the unusually large amount of ferrous oxide it contains. There is no perceptible dichroism.

A section perpendicular to the direction of the fibres[2] shows no dark cross or rings in convergent polarised light. In parallel light, with crossed nicols, the field is rather brightly illuminated, and rotation of the nicols together does not alter the illumination. A cylinder of the fibres, again, lying parallel to the stage of the microscope, exhibits double refraction, and no alteration in the phenomenon is observable during a rotation of the cylinder on its own axis. The optical elasticity is greater in the direction of the fibres than transverse to them. The above observations are in consonance with the statement of Lévy and Lacroix, that in nemalite "les fibres sont allongées suivant un des côtés de l'hexagone et négatives,"[3] and, with the optically positive character of brucite, nemalite included. But they apparently indicate that the vertical crystallographic axes, *c*, in the different fibres (which are so minute that in a cross section they are individually quite invisible

[1] Dr. Hidden, who was present when this note was read, remarked that the Nemalite of Hoboken, N.J., shows a similar obliquity between the direction of the fibres and that of the walls of the vein.

[2] I am indebted to Professor J. W. Judd, C.B., for kindly having the section cut for me, and also for several references bearing on the subject of brucite.

[3] *Les Minéraux des Roches*, 1888, p. 162.

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under the microscope[1]) lie, not in parallelism with each other, but in varying directions in the plane perpendicular to the cross section of the fibres.

The value obtained for the specific gravity, at 60° F., is 2·454; a high result, which must be ascribed to the large amount of iron present.

The mineral (free from hygroscopic moisture) gave on analysis:—

		Oxygen ratio.[2]	
Magnesia	62·00	24·58	26·33 (or 1·003)
Ferrous Oxide ...	7·87	1·75	
Manganous Oxide...	trace		
Water	29·55		26·24 (or 1)
Silica	·38		
	99·80		

A faint trace of lime was detected spectroscopically.

The only point in which the above figures differ noticeably from Mr. Blyth's is in the smaller amount of iron; but the sample used in his analysis was from a different specimen, obtained at a different time, and possibly from a different part of the vein; and more or less variance in the relative proportions of the isomorphous oxides is what might be expected.

The silica is left undissolved by hydrochloric acid, in the form of translucent tangled fibres, which dissolve in a hot solution of sodium carbonate. They are indistinguishable in appearance from the siliceous fibres which remain when chrysotile is decomposed by the same reagent. As nemalite and chrysotile are usually found under similar conditions—in the form of veins traversing serpentine—it seems not unnatural that the two allied magnesian fibrous minerals should co-exist intimately mixed in the same vein, and it appears not improbable that such is the case in the substance under discussion.

If, then, the silica be regarded as a constituent of chrysotile, and to the latter be assigned the theoretical composition of the mineral, with the magnesia and iron in the same proportions relatively to each other as in the nemalite, the above analysis will stand as follows:—

---

[1] With linear magnification of 180.

[2] Mg = 24·36, Fe = 56·00, H = 1·0076

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	Chrysotile.	Nemalite.	Calculated to 100.	Oxygen Ratio.	
Magnesia ...	·35	61·65	62·32	24·71	26·47 (or 1·001)
Ferrous oxide ...	·04	7·83	7·92	1·76	
Manganous oxide	—	tr.	tr.		
Water	·11	29·44	29·76		26·43 (or 1)
Silica	·38				
	·88	98·92	100·00		
	99·80				

Granting the existence of the chrysotile, whether it should be regarded as formed synchronously with the nemalite, or as present owing to one mineral having been altered into the other, I do not know. As previously remarked, the substance analysed showed no indication of change unless the presence of silica be regarded as such. On the other hand, a portion of the substance near the end of the specimen, where it was obviously changed, contained 2·26 per cent. of silica fibres, = 5·28 per cent. of chrysotile, or six times as much as the portion fully analysed. But this excess of silica was accompanied by the presence of carbonic acid and ferric oxide, which might, therefore, perhaps be expected to accompany the smaller amount of silica (·38 per cent.) also, if the latter were due to alteration of the nemalite; and the larger percentage of silica may be caused merely by original unequal distribution of chrysotile through the specimen.

Near the ends of the specimen the original green colour is changed to a light hair-brown, the mineral still retaining its translucency, the alteration being due to a very partial peroxidation of the iron. Beyond that, again, the fibres are white, with a pale reddish tinge, and comparatively opaque. This portion (besides the silica mentioned above) contains a considerable quantity of carbonic acid, owing to the nemalite having been more or less fully converted into hydromagnesite; and the ferrous is largely, or entirely, changed to ferric oxide. There is also a certain amount of non-fibrous and scaly, or in part stellate-lamellar, hydromagnesite on the ends of the specimen, which was formed, apparently, by deposition on the nemalite, not by alteration *in situ*. This hydromagnesite encloses some magnetite, which may perhaps be taken as representing part of the ferrous oxide of the nemalite (from some other portion of the vein), from which the deposited hydromagnesite was probably formed.

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Note on Altaite from Burma.

By Henry Louis, M.A., A.R.S.M., F.I.C., F.G.S., Professor of Mining in the Durham College of Science, Newcastle-upon-Tyne.

[Read February 2nd, 1897].

BY the kindness of Mr. A. H. Bromly, Manager of the Choukpazat Gold Mining Company's mines at Choukpazat, Wuntho, Upper Burma, I have received a few hand-samples of the veinstuff from these mines. The vein runs in clay slate or chloritic slate, parallel apparently to the bedding, with a strike north-east to south-west, and a dip of 20° to 25° to the south. The veinstuff, to judge from the samples submitted to me, consists of white, somewhat saccharoidal quartz, with some calcspar, and contains iron pyrites, arsenical pyrites, visible free gold (rather pale in colour and apparently rich in silver), and the mineral that forms the subject of the present note. The latter generally occurs together with comparatively coarse gold in the richer portions of the vein, finely crystalline, though no distinct crystals can be made out, and very minutely disseminated, no particle larger than about 0·05 of an inch having been seen by me. The mineral is tin-white, with a somewhat yellowish tinge, has a high metallic lustre, and is quite opaque. It appears to be brittle; the broken particles show very perfect cleavage, which, under the microscope, can (probably with safety) be pronounced to be cubical. The hardness is 2-3. No particles sufficiently large for a determination of its specific gravity could be obtained.

I succeeded in separating 0·375 grain in a state of approximate purity for an analysis. With so small a quantity at my disposal, a high degree of accuracy was of course out of the question. The mineral was completely decomposed by moderately concentrated sulphuric acid, sulphate of lead being formed, whilst tellurium went into solution. The composition found was the following:—

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Tellurium	34·2	91·6
Lead	57·4	
Iron	0·2	6·1
Calcic Carbonate	3·8	
Silica	2·1	
	97·7	

Silver was present, but not in determinable quantity.

Calculating the percentage composition upon the two essential elements, the above ratio corresponds to—

Tellurium	37·4
Lead	62·6
	100·0

This composition answers very closely to the formula PbTe, the percentage composition required by which is as follows—

Tellurium	37·9
Lead...	62·1
	100·0

The correspondence thus shown is sufficiently close to enable me to identify the mineral as the altaite of Dana, although it appears to differ from the latter in some of its physical properties, *e. g.* in being brittle instead of sectile, and in its somewhat lower hardness. These differences may possibly be due to the minute state of dissemination of the Burmese mineral.

With respect to the relative age of the various minerals, nothing very definite can be observed, but the altaite and some of the other metallic minerals seem to be filling minute hollows or cracks in the quartz. In one instance the microscope showed a minute film of gold deposited between the cleavage planes of the altaite.

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NOTES AND COMMENTS.

THE deplorable death of Baron Heinrich von Foullon, at the age of 46, has closed a career of active work in Mineralogy and Geology. Baron Foullon, who was Geologist at the Geological "Reichsanstalt" at Vienna, was a member of the unfortunate exploring expedition sent to the Solomon Islands by the Austrian Government. The whole party of explorers was massacred by the natives in August 1896.

Baron Foullon was a voluminous writer, and published papers on a number of subjects of mineralogical and geological interest, especially in relation to Petrology.

The death of Dr. J. W. Retgers, of Haag, removes an equally energetic student from the physical and chemical side of Mineralogy. Dr. Retgers, who was for many years occupied in Java, only devoted himself comparatively late in life to Chemistry and Crystallography, but displayed a marvellous activity, of which the record remains in a long series of papers upon Isomorphism and kindred subjects, published mostly in the *Zeitschrift für Physikalische Chemie.*

Another familiar name which disappears from the list of active workers is that of Dr. August Streng, for many years Professor of Mineralogy in the University of Giessen, where he was recently succeeded by Dr. Brauns. Professor Streng died on the 7th of January, at the age of 66.

A notable event is the completion of a volume of Professor Hintze's colossal *Handbuch der Mineralogie*, of which the first instalment was issued in 1889. Attention was called to the commencement of this great undertaking in Vol. IX. p. 48 of this Magazine, where it was mentioned that Professor Hintze hoped to complete the undertaking in 3 or 4 years. The first volume alone has occupied more than 7 years, and

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this is by no means surprising. The volume contains no less than 1831 pages of closely printed material, and deals with the silicates and titanates with a luxuriance of detail never before attempted. Complete accounts of all the occurrences and associations are given for all the known localities, in addition to the general characters of each mineral. For example, the description of anorthite alone occupies 20 pages, contains 14 figures, a list of 94 angles, an account of 81 analyses, and a description of about 80 localities. The work is an invaluable book of reference, since it contains all that is to be found in other descriptive treatises and a great deal more besides, and appears to be extraordinarily accurate. The present volume is to be the second volume of the treatise, although it has been issued first.

A treatise of almost equal detail, but confined to the minerals of France and her colonies, is also completed, so far as the silicates and titanates are concerned, by the recent issue of the first part of the second volume of Professor A. Lacroix's *Minéralogie de la France et de ses Colonies;* the first volume of which was reviewed in Vol. X. p. 168 of this Magazine. This valuable treatise will ultimately consist of 3 volumes.

We have received a Catalogue of the Minerals of Tasmania, by W. F. Petterd (Launceston, 1896), a little book which contains a descriptive account of all the mineral occurrences hitherto known in that island.

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REVIEWS.

Manual of Determinative Mineralogy, with an introduction on Blowpipe Analysis. By George J. Brush. Revised and enlarged by Samuel L. Penfield. 14th Edition. 164 pp. and Tables. London: Chapman and Hall. 1896.

Professor Brush's work on the determination of minerals by the aid of the blowpipe evidently meets a need, for it has run through 13 editions since its appearance in 1874, and it has now been found desirable to re-issue it in a semi-revised state under the editorship of Professor Penfield, whose name on the title page is a guarantee that the 14th edition will not fall behind its predecessors in usefulness.

The work in its present form consists of an introduction, followed by chapters on Apparatus and Reagents, Reactions of the Elements, Summary of Reactions and Tables for the Determination of Minerals.

The chapter entitled "Introduction and Chemical Principles" provides us with definitions of atomic weights, valence, chemical affinity, and the like, and instructs us how to calculate the formula of a mineral from its percentage composition. The judicious reader will skip all this, for if skilled in chemistry he will have nothing to learn from it, and if a beginner will be none the better for its perusal, and can more profitably occupy his time in learning the elements of his subject than in studying a book which should only be in the hands of those who have already obtained some knowledge of chemistry. The account of apparatus and reagents does not differ materially from that contained in other text books. The descriptions are clear, and so thoroughly illustrated by excellent drawings that no difficulty ought to be found in following them. In a book planned on a somewhat ambitious scale and of comparative costliness, we may fairly expect comprehensiveness of treatment, and it is therefore with a sense of disappointment that we search in vain for an account of the use of the spectroscope and for a table of spectra, and find no mention of Bunsen's flame reactions or of the aluminium plate support introduced by Ross. The distinctive and valuable feature of the book is, no doubt, the detailed account of the reactions of the elements and the summary of the same, contained in the third and fourth chapters.

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The author does not limit himself to the blowpipe characters merely, but wisely includes the more important of the "wet" tests as well, and gives us in small print much excellent advice as to the quantities to take and the best conditions to employ to ensure the success of the experiments. These hints are evidently the result of much laboratory experience, and the student of mineralogical chemistry will do well to take them to heart.

The concluding chapter is occupied by Professor Brush's edition of von Kobell's well-known tables for the determination of minerals. Criticism of these is superfluous, more especially in view of the somewhat irritating statement made in the preface that the tables are even now under revision, and will be issued as soon as possible, together with a short chapter on crystallography and the physical properties of minerals.

We greatly regret that Professor Penfield was unable to complete the revision before the publication of this edition; for, had he done so, its value would have been greatly enhanced, and most mineralogists would have been content to wait indefinitely for the chapter on crystallography, if only the tables had been brought up to date. Even in its present state the book is one which ought to be found in every mineralogical institute in the English-speaking world. A. H.

Max Bauer. *Edelsteinkunde, eine allgemein verständliche Darstellung der Eigenschaften, des Vorkommens und der Verwendung der Edelsteine, nebst einer Anleitung zur Bestimmung derselben.* 711 pp. 20 coloured plates, 94 woodcuts. Tauchnitz, Leipzig, 1897.

This attractive book, to which attention was called in this Journal (Vol. XI. p. 92) on the appearance of the first part, is now complete. The excellent coloured plates, representing both natural and facetted stones, which were, according to the prospectus, to have been eight in number, have ultimately reached the number of 20, and are the most striking feature of the book. The only coloured plates of gem-stones, or indeed of minerals of any form, which can be compared with them are those which adorn Kunz's well-known work on the precious stones of North America.

Professor Bauer's treatise, though containing much that is of popular interest, is by no means a mere popular book for the general reader. It professes to be designed for mineralogists, lapidaries, and jewellers, and is full of scientific information. The first 124 pages are occupied with the general properties of minerals, in which the reader will find a full account of the various methods of determining the specific gravity, the

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hardness, the optical and other physical characters, of gem-stones; a chapter on their applications—on the forms of facetted stones, and on the method of facetting; on their engraving, colouring and mounting; on imitation jewels, and on the comparative value of the various stones. All this is told in a simple and intelligible manner, and should be of the greatest practical value for the class of readers for whom it is designed; equally with the remainder of the book, this part may be recommended to every mineralogist as containing valuable and interesting information not easily found elsewhere; and it teems with useful hints and explanations.

It is doubtful whether the method of estimating specific gravity (given on p. 27) by means of four standard mixtures of methylene iodide and benzene is so reliable as might be imagined from the description. In practice such mixtures so rapidly increase in density owing to evaporation of the benzene that they would require continual re-determination, and it is far easier to work always by comparison with standard indices of known minerals, and to dilute the heavy liquid as required.

We miss one method that deserves description in a treatise on the determination of gem-stones, on account both of its scientific interest and practical value, namely, Kundt's method of exhibiting the pyroelectricity of tourmaline by dusting a cooling crystal with a mixture of red lead and sulphur. This is not alluded to either in the first chapter nor yet in the description of tourmaline, and yet it is in reality a most useful method of testing a tourmaline, and one which can often be easily applied even to a mounted stone.

We miss also any allusion to the method of determining the refractive power of a gemstone by means of total reflection. The reflectometer is an instrument so easily used and so convenient for the examination of stones, whose index of refraction is less than that of methylene iodide or of monobromo-naphthalene, that it might well have been described.

The remainder of the treatise deals with the various gem-stones in succession; and here the reader will find copious information about the occurrence and association of the different minerals on a far larger scale than has been previously attempted by books of this class. All the more important localities are explained by means of sketch maps, and the descriptions, historical, geographical and mineralogical, of the regions in which diamonds, rubies, lapis lazuli, and the other minerals have been worked, are most complete.

Under quartz (agate) will be found a very interesting illustrated account of the famous cutting and polishing industry of Oberstein.

The book is one which stands quite alone at present as a scientific

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treatise on precious stones in all their modern aspects, and should be of great use.

Among the coloured figures special attention should be called to the highly successful representation of emeralds on Plate 12, of topaz on Plate 13, and of garnets on Plate 14.

The volume closes with a chapter on the identification of precious stones, and an appendix on pearls and coral. H. A. M.

Crystallography for Beginners by C. J. Woodward, B.Sc. London, 1896.

Few chemists are likely to question the value of the study of crystals as an aid to the accurate determination of the products of the organic laboratory. Many, however, seem to be of the opinion that crystallography is a subject of such an abstruse and mathematical character, that it is hopeless to attempt its mastery. This unfortunate misconception has no doubt been fostered to some extent by the lack of elementary text books to lead the beginner by easy stages up to the study of those more elaborate treatises which at first sight appear formidable to students without mathematical training. All, therefore, who are anxious to see fresh interest aroused in the study of crystals will welcome the little book before us, which in a simple, yet accurate and logical manner, sets forth within the limits of nine short lessons the chief facts and principles of the science.

Anyone who works conscientiously through the text and the illustrative examples at the end of each section, cannot fail to obtain a good grasp of the meaning of symmetry, the law of rational indices, the Millerian notation, and the method of representing the faces of crystals by means of the stereographic projection.

It should, however, be noted, that in making a projection of a crystal the eye is usually imagined as placed at the south pole of the sphere and not at the north pole, as represented in fig. 16. The concluding lessons are devoted to the forms of the cubic system, the choice of axes and parameters, Naumann's notation, the physical properties of crystals, and an explanation of the meaning of hemihedrism. At p. 100 the author's work and the scientific interest of the book cease together, for the appendix, some 60 pages, is given over to an entirely separate treatise, a translation from the German of Dr. Weisbach of a series of directions for identifying minerals by the application of simple tests. That tables of this sort have a certain value cannot be denied; but at the end of a work on crystallography they seem out of place—a chapter on organic

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chemistry would hardly be more incongruous; and it is greatly to be regretted that they should have been allowed to monopolise space which could have been so much more profitably devoted to a consideration of twins, the forms of most of the systems, and the 32 crystal classes, all of them points passed over in silence in the body of the work. As far as it goes, however, the book is certain to prove useful to the beginner, and it will, we hope, do much to render more popular a fascinating and useful but neglected subject. A. H.

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Abstracts.

Pearceite, and the crystallisation of Polybasite (S. L. Penfield, *Amer. Journ. Sci.* [4], II. 17-29, 1896). As corresponding sulpharsenites and sulphantimonites usually receive different designations, the name pearceite, after Richard Pearce, is proposed for the arsenical varieties of polybasite, $9Ag_2S.Sb_2S_3$—pearceite being $9Ag_2S.As_2S_3$. Minerals to which this name can be applied are:—the arsenical polybasite from Schemnitz, analysed by H. Rose in 1833; that of Aspen, Colorado, described by Penfield and S. H. Pearce in 1892; and the mineral described in the present paper. Two other old analyses show arsenic and antimony in about equal molecular proportions. The mineral here described occurs beautifully crystallised at the Drumlummon Mine, Marysville, Lewis and Clarke Co., Montana. Analysis by F. C. Knight gave—

S	As	Ag	Cu	Fe	Insol.	Total
17·71	7·39	55·17	18·11	1·05	0·42	99·85

This gives $S : As : (Ag_2+Cu_2+Fe)$ as very nearly 12 : 2 : 9, as is required by the above formula, with $Ag_2 : Cu_2 : Fe = 255 : 143 : 19$. The monosymmetric crystals are usually flat hexagonal tablets, often with highly modified edges. There is a close approach to rhombohedral symmetry, so that it is often difficult to distinguish between the zones [001 : 100] and [001 : 110].

$$a : b : c = 1·7309 : 1 : 1·6199\,;\ \beta = 89°51'\,;\ mm = 60°2'.$$

On the basal plane are triangular markings, and the crystals show indications of twinning on the same law as the micas and chlorites. The colour and streak are black; lustre metallic; opaque, even in thin splinters. Sp. gr., 6·15. Brittle, with no distinct cleavage.

Polybasite, which has been described as being rhombohedral, and more recently as orthorhombic, is here shown to be monosymmetric. A crystal from Himmelfahrt mine, Freiberg, is described, which consists of a rhombohedron with the basal plane; this would be difficult to explain if the mineral were orthorhombic. It is pointed out that the monosymmetric minerals, mica, chlorite and leadhillite, which have prism angles of nearly 60°, exhibit this tendency to simulate rhombohedral symmetry,

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which is not the case with the orthorhombic minerals, copper glance, aragonite and witherite. Measurements of unusually perfect crystals from Yankee Boy Mine, Ouray, Colorado, gave—

$$a : b : c = 1{\cdot}7309 : 1 : 1{\cdot}5796\,;\ \beta = 90°0'\,;\ mm = 60°2'.$$

These parameters of pearceite and polybasite show that there is a tendency for arsenic to increase the length of the vertical axis, and this is also to be noticed in several other cases—for example, in proustite and pyrargyrite. A close similarity is pointed out between these parameters and those of copper glance (Cu_2S) and stromeyerite (CuAgS) and many sulpharsenites and sulphantimonites, all of which have a prism angle of nearly 60°. This would seem to indicate that the sulphide of the metal has had a controlling influence on the crystallisation. L. J. S.

Rathite, a new Binnenthal Mineral (H. Baumhauer, *Zeits. für Kryst.* XXVI. 593-602, 1896). The sulpharsenites of lead — jordanite, dufrenoysite, and sartorite—are all very similar in appearance, and a close examination of them leads to the conclusion that there is at least one more—namely, rathite—to be found amongst these Binnenthal minerals. Characteristic of rathite, but not invariably present, are parallel systems of very fine striæ, which are visible, with a suitable oblique illumination, on the crystal faces and on the fractured surfaces ; this striation is oblique to the zone axis on the macrodomes, and is evidently due to a lamellar structure (which may be isomorphous banding or twinning) of the crystals, in which the lamellæ are parallel to the faces of a brachydome, possibly (011). The crystals are orthorhombic, and resemble those of the minerals mentioned above in being elongated and striated parallel to the macro-axis, and in often being indistinctly terminated. The list of crystal forms includes the basal plane, 4 brachydomes and 20 macrodomes.

$$a : b : c = 0{\cdot}668099 : 1 : 1{\cdot}057891.$$

Multiplying a and c by $\frac{3}{2}$, there is a close relationship between these parameters and those of dufrenoysite. The crystals are twinned, probably on a brachydome, so that the striated zones of two individuals intersect at an acute angle; there is, however, no relation between this twinning and the fine striation.

Sp. gr. 5·32. Analysis by A. Bömer gave :

Pb.	S.	As.	Sb.	Fe.	Total.
52·98	23·72	17·24	4·53	0·56	99·03

A mixture of 5 molecules of dufrenoysite ($2PbS.As_2S_3$) and 1 of jamesonite ($2\,PbS.\,Sb_2S_3$) does not correspond so closely to this composi-

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tion as does a mixture of 5 molecules of $2PbS.As_2S_3 + 2PbS.As_2S_5 = 4(PbAsS_3)$ and 1 of $2PbS.Sb_2S_3 + 2PbS.Sb_2S_5 = 4(PbSbS_3)$. It is supposed that the fine striæ are due to the alternate banding of these two isomorphous compounds, and that the partial replacement of As_2S_3 and Sb_2S_3 by As_2S_5 and Sb_2S_5 accounts for the morphotropic relationship between rathite and dufrenoysite. The mineral is named after the late G. vom Rath. L. J. S.

Wardite, a new aluminium phosphate (J. M. Davison, *Amer. J. Sci.* II. 154-155, 1896). This occurs in cavities in the nodules of variscite from Utah; it is light green or bluish green in colour with a vitreous lustre. The structure is concretionary; sp. gr. 2·77; H. about 5, being a little harder than the variscite. Analysis gave—

P_2O_5	FeO	CuO	MgO	Na_2O	K_2O	H_2O	Al_2O_3 [diff.]
34·46	0·76	0·04	2·40	5·98	0·24	17·87	[38·25]

Formula, $P_2O_5.2Al_2O_3.4H_2O = Al_2(OH)_3PO_4 + \frac{1}{2}H_2O$; or perhaps $AlNaPO_4.Al(OH)_3.\frac{1}{2}H_2O$. The following series is made out:—

Peganite	$Al_2(OH)_3PO_4 + 1\frac{1}{2}H_2O$
Turquoise	$Al_2(OH)_3PO_4 + 1H_2O$
Wardite	$Al_2(OH)_3PO_4 + \frac{1}{2}H_2O$

Before the blowpipe the mineral swells up and turns white; it is only partially decomposed by aqua regia. The name is given after H. A. Ward. L. J. S.

Northupite, Pirssonite and Hanksite from California (J. H. Pratt, *Am. J. Sci.* II. 128-135, 1896). The minerals here described are found associated with borax and gaylussite at Borax Lake, San Bernardino Co., California. Borax Lake is an alkali marsh which is usually dry, but some water collects in it during the wet seasons.

Northupite (see Abstr. XI. 159).—An analysis of this new mineral agrees closely with the formula $MgCO_3.Na_2CO_3.NaCl$; potassium is absent. Sp. gr. 2·380. It is isotropic, and for sodium light $\mu = 1·5144$. [Artificial northupite has been recently prepared by A. de Schulten (*Bull. Soc. franç. Min.* XIX. 164, 1896.)].

Pirssonite. This new mineral has been found as isolated orthorhombic crystals with northupite. It is hemimorphic, and shows the forms $b\{010\}$, $m\{110\}$, $p\{111\}$, $p^{\circ}\{11\bar{1}\}$, $e\{131\}$, $x\{311\}$; $a : b : c = 0·56615 : 1 : 0·3019$. The crystals vary considerably in habit, being prismatic, or tabular parallel to b. The form e is developed at only one end, this being the

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pyro-electric analogous pole. The mineral is colourless to white, but is often darkened by impurities; it is brittle, and shows no cleavage; Sp. gr. 2·352; H = 3 – 3·5. The plane of the optic axes is the base, and the axis *b* is the acute bisectrix; optically positive; $2E_{Na} = 48°16'$ at 20° C., and 47°38′ at 90° C. Chemical analysis gives the formula $CaCO_3.Na_2CO_3.2H_2O$; this is like gaylussite, which, however, has $5H_2O$; the two minerals are also somewhat similar in appearance, and occur together. Practically all the water is expelled below 150°. The name is given after L. V. Pirsson. [De Schulten has prepared artificial pirssonite alone, and also simultaneously with northupite and gaylussite; in the latter reaction rhombohedral crystals of $MgCO_3.Na_2CO_3$ were also formed, and it is predicted that this will be found as a natural mineral at Borax Lake (*Compt. Rend.* CXXIII. 1023, 1896).]

Hanksite.—The formula usually accepted for this mineral is $4Na_2SO_4.Na_2CO_3$; and the potassium and chlorine in the two previous analyses have been considered as impurities (salt and sylvine). The author, however, finds that chlorine is present in all crystals, and that microscopical examination shows the presence of only slight impurities. The following analyses have been made on pure material, I. on tabular crystals, and II. on prismatic crystals—

	SO_3	CO_2	Na_2O	Cl	K	Insol.	Sp. gr.
I. ...	45·96	5·65	43·35	2·21	2·48	0·19	2·567 – 2·553
II. ...	45·78	5·63	43·61	2·28	2·39	0·12	2·545

The close agreement of both these with previous analyses indicates that chlorine and potassium are not accidental. The formula is now given as $9Na_2SO_4.2Na_2CO_3.KCl$. Few minerals contain three acid radicles, as this does.

[Artificial hanksite prepared by de Schulten has the composition $4Na_2SO_4.Na_2CO_3$ (*Compt. Rend.* CXXIII. 1325, 1896).] L. J. S.

Gold in Granite (G. P. Merrill, *Amer. J. Sci.* [4], I. 309-311, 1896). A specimen labelled "Gold ore, Sonora, Mexico" is an ordinary black-mica granite which, owing to weathering, is brown and friable; throughout the mass are numerous specks, rarely over 1 mm. in diam., of native gold. Pyrites and other sulphides are absent. Microscopical examination of thin sections of the rock shows the gold enclosed in the quartz and felspar as beautiful arborescent and platy forms; it therefore does not seem to be a secondary constituent, which has been deposited along fissures, but to be a primary constituent which has crystallised from the original magma. Such a mode of occurrence of gold does not seem to have been previously described. L. J. S.

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Valleite, a new orthorhombic Amphibole (G. Cesàro, *Bull. Acad. Sci. Belg.* [3], XXXII. 536-545, 1896, and XXIX. 508-510, 1895). This mineral occurs with the violet tremolite (hexagonite) of Edwards, St. Lawrence Co., N.Y. It closely resembles anthophyllite in appearance, but differs from it in the optical characters, and in containing only a little iron. The indistinct crystals are flattened parallel to (100), and have a perfect cleavage in this direction. Other cleavages are (010), (021), and less distinct (110), (011), (031) and (001). The prism angle is 54°30′; $a:b:c=0{\cdot}515:1:0{\cdot}255$. The plane of the optic axes is (010), and the acute negative bisectrix is perpendicular to (100); $2E=90°28'$; H = 4·5; sp. gr., 2·88. It is easily fusible to a white, nearly opaque, bead. Analysis by Renard gave—

SiO_2	MgO	CaO	Fe_2O_3	MnO	K_2O	H_2O	Total
58·02	27·99	5·04	1·28	2·88	0·89	3·13	99·23

This agrees with the metasilicate formula $RO.SiO_2$. L. J. S.

Heavy Liquids for the separation of Mineral Sulphides (J. W. Retgers, *Neues Jahrb. Min.* I. 212-221; II. 183-195, 1896). As molten silver nitrate and silver-thallium nitrate (m.p. 70°, sp. gr. 4·8) act on mineral sulphides, these liquids have only a limited application. The author has examined numerous simple and double nitrates and acetates of the heavy metals, with the object of finding a colourless, mobile liquid of high density, which is miscible with water, and would be applicable in the case of sulphides. The most useful is thallium-mercurous nitrate (m.p. 76°, sp. gr. 5·3). Thallium acetate (m.p. 110°, sp. gr. 3·9) has too low a density, and thallium nitrate-acetate (m.p. 65°, sp. gr. 4·5) decomposes at temperatures above 100°. Mercurous nitrate, $HgNO_3+H_2O$ (m.p. 70°, sp. gr. 4·3) is much less expensive than the other salts. L. J. S.

Crystallography of Bournonite (F. B. Peck, *Zeits. f. Kryst.* XXVII. 299-320, 1896). Taking c(001) and b(010) of bournonite to be (100) and (001) respectively, it is seen that there is a close crystallographic, as well as chemical, relationship between this mineral and the monosymmetric members of the red silver group.

		a	b	c	β
Xanthoconite	Ag_3AsS_3	1·9187 :	1 :	1·0152	88°47′
Fireblende	Ag_3SbS_3	1·9465 :	1 :	1·0973	90 0
Bournonite	$PbCuSbS_3$	½(1·9122) :	1 :	1·0662	—

This suggests that bournonite may be monosymmetric; but the angular

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measurements, some of which were made at different temperatures, and the results of thermal conductivity experiments, are in agreement with orthorhombic symmetry. The crystals of bournonite from various localities are described in detail. L. J. S.

Tilasite or Fluor-adelite from Långban (H. Sjögren, *Geol. Fören. i Stockholm Förh.*, 1895, XVII. 291-294; Abstr. in *Neues Jahrb. Min.* 1897, I. 25-26). Irregular grains, 5-10 mm. across, of this new mineral are found with hausmannite, berzeliite and calcite in a grey limestone at Långban, Sweden It is grey to pale violet in colour; the lustre on the fractured surfaces is greasy, and on the cleavage surfaces vitreous. The formula is $2CaO.MgO.MgF_2.As_2O_5$, this being like that of adelite, but with fluorine in place of (OH). The optical examination of cleavage flakes shows the mineral to be anorthic. L. J. S.

Mauzeliite (H. Sjögren, *Geol. Fören. i Stockholm Förh.* 1895, XVII. 313-318; Abstr. in *Neues Jahrb. Min.* 1897, I. 26-27). Mauzeliite occurs, with a rose-red mineral which is probably svabite, in a calcite vein 1—2 cm. wide, in a mixture of hausmannite, calcite, garnet, schefferite and manganophyllite, at Jakobsberg, Sweden. The isometric crystals are 5—10 mm. across, and show the forms (111), (100), with sometimes (311). (111) is usually even, (100) pitted, and (311) striated parallel to its intersection with (111). The mean of two analyses made by Mauzelius has already been quoted on page 83 of this volume; neglecting the fluorine, which could not be determined, the formula is deduced as $Ti(SbO_4R'')_4 = 4R''O.2Sb_2O_5.TiO_2$. L. J. S.

Hullite (G. A. J. Cole, *Proc. Belfast Nat. Field Club*, 1894-5, IV, 221; *cf.* Abstr. II, 152, 247). This substance has been described as filling amygdaloidal cavities, and as occurring interstitially among the minerals of the basalt. Having in view the latter mode of occurrence, the author suggests that hullite is really the altered and hydrated glass of the original basaltic groundmass; the chemical composition being near to that of a palagonite. The occurrence of a glass in vesicles has already been described by Teall in the Tynemouth dyke. L. J. S.

The so-called Schneebergite (A. S. Eakle and W. Muthmann, *Zeits. für Kryst.*, XXIV, 583-6, 1895). This mineral, which occurs as small honey-yellow, regular octahedra at Schneeberg, Tyrol, was stated by Brezina to consist principally of calcium, antimony and a little iron (*cf.*

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Abstr. V, 112); it has, therefore, been considered to be near, or to be identical with, atopite. From the analysis of the present authors, it is, however, seen to be really a calcium-iron-garnet, no Sb, Bi, or Cu having been detected.

SiO_2	Fe_2O_3	CaO	Sp. gr.
35·45	32·22	32·58	3·838

The material consists of aggregates of rounded crystals, associated with magnetite, blende, copper pyrites and quartz; on other specimens it is as a thin coating, with here and there distinct octahedra. The crystals are isotropic, with the exception of anomalous double refraction round enclosed grains of magnetite, blende, &c. The mineral is always associated with calcite and braunnerite, which it often surrounds, and from which, under the microscope, it is distinctly seen to have been derived. The occurrence of a topazolite without any alumina and in octahedra is of interest. L. J. S.

Composition of Idocrase (Mats Weibull, *Zeits. f. Kryst.*, XXV, 1-37, 1895). The author has examined the idocrase from the limestone quarry of Tennberget, Dalarne, Sweden, its mode of occurrence and that of the associated minerals being minutely described: of interest is the fact that the calcite in contact with the idocrase is very pure, containing only MgO (0·14 per cent.). The crystals are rich in forms (the prism 650 new), and the measurements agree completely with the tetragonal system: $a : c = 1 : 0{\cdot}53539$ (from $cp = 37°7'54''$), there being only a slight variation in the angles of different crystals. The mineral is uniaxial and negative, and shows no division into fields. Colour, brown; sp. gr. 3·325. The mean of six partial analyses on a crystal with $cp = 37°10'30''$ gave the results under I. For this the orthosilicate formula $12CaO.3Al_2O_3.10SiO_2.(H_2O,F_2)$ is deduced, the alkalies being reckoned as R″O. The loss on ignition is slightly greater than H_2O+F, and experiments were made which tend to show that the white fumes evolved on ignition consist of AlF_3.

	SiO_2	Al_2O_3	B_2O_3	Fe_2O_3	FeO	CaO	MnO	MgO	K_2O
I.	37·38	16·92	—	1·78	3·36	35·01	0·06	2·20	0·23
II.	37·97	16·25	0·10	3·87	0·55	35·34	—	2·46	0·13

	Na_2O	H_2O	F	Total	Total (0 less F)
I.	1·15	0·77	1·72	101·03	100·30
II.	0·28	1·08 1·60	—	99·63	

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Previous analyses, in which the water and fluorine have been directly determined, are reduced to the above formula. A structural formula showing the relation to garnet is given.

Some fluorine-free idocrases have also been examined; crystals from Cziklowa, Hungary, with $a : c = 1 : 0{\cdot}5340$, $cp = 37°0'$, and showing optical anomalies, gave the analysis II. This analysis agrees with the above formula when the water is considered as partly an acid and partly a basic constituent; this is supported by the fact that part of the water (1·08 per cent.) goes off at a red-heat, while the remainder is only expelled at a very high temperature over the blowpipe, the former part being considered to be the basic and the latter the acid water. An optically normal crystal ($cp = 37°13'$) from Zermatt lost water in the same manner. Previous analyses of fluorine-free idocrases are discussed, and in the formula of some the radicles Al(OH), Mg(OH) or Ca(OH) are supposed to exist with the bases. It is noticed that although the amounts of the other bases vary, the calcium is pretty constant (35 per cent.); this represents $\frac{5}{6}$ R″, and the general formula is $Ca_3R''Al_2[R'''(OH,F)]Si_3O_{20}$. No connection can be traced between the variation of the ratio $a : c$ and the chemical composition. L. J. S.

Crystalline form of Riebeckite. (W. J. Sollas, *Proc. Roy. Irish Acad.* [3], III, 516-523, 1895.) Rock fragments from the glacial deposits of the east coast of Ireland are identified with the micro-granite of Ailsa Craig (*Min. Mag.* IX. 219) in containing riebeckite, but they otherwise closely resemble the granophyre of the Mourne Mountains district. In these rock fragments are numerous drusy cavities containing crystals of quartz, felspar and riebeckite, the latter up to 5mm. in length. The crystals are somewhat irregular, the faces not being quite parallel, but there is no reason for not considering the mineral as monosymmetric.

$$a : b : c = 0{\cdot}54748 : 1 : 0{\cdot}29246\,; \quad \beta = 76°10'.$$

Forms, b(010), c(001), m(110), Z(150), $r(\bar{1}11)$, $t(\bar{2}01)$, z(021), with b m c about equally developed, the other planes being small; $mm = 56°$. Partial analyses gave:

SiO_2	Al_2O_3, Fe_2O_3	Na_2O	K_2O
42·69	41·71	10·00	0·87

Brögger's statement that the extinction angle of the hornblendes varies with the amount of soda and iron is represented graphically. L. J. S.

Pyrochlore from Alnö, Sweden. (P. J. Holmquist, *Geol. För. Förh.*, XV, 588, 1893; abstr. in *Neues Jahrb. Min.* II, 15-16, 1895.) In the

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metamorphic limestone of the syenite district of the above locality occur numerous octahedral crystals of pyrochlore, together with titaniferous magnetite, apatite, olivine, manganophyllite, zircon and perofskite. Besides (111) the forms (110) and (100) are present. The larger crystals (1 – 2 cm. across) are of a light brown to black colour and have a sp. gr. of 4·3528 – 4·3533 (analysis I), while the smaller crystals are transparent and of a light reddish-yellow colour, having a sp. gr. of 4·4160 (II). In sections, the mineral is fresh and isotropic, and an octahedral cleavage is sometimes apparent. A zonal structure is seen, which in the larger crystals presents itself as alternate brown and light-yellow zones, the former broader towards the centre of the crystal and the latter broader towards the periphery; also sometimes the smaller crystals have a dark kernel which shows the zonal structure.

	Nb_2O_5	TiO_2	ZrO_2	FeO	Ce_2O_3	ThO_2	CaO	Na_2O
I.	58·83	3·70	2·90	4·20	3·99	0·41	16·75	3·44
II.	63·64	—	4·90	1·14	4·86	—	18·13	4·99

	K_2O	H_2O	F	Total.	Total (less O for F).
I.	1·41	0·78	4·34	100·75	98·92
II.	0·60	0·47	4·31	102·54	100·73

These analyses may be represented by the general formula $m(2RO.Nb_2O_5) + RO.(Zr,Ti)O_2$. In II. there is enough fluorine to replace all the oxygen in the metazirconate, and $m = 6$, so that the formula becomes $6\,(2RO.Nb_2O_5) + RF_6Zr$, or

$$\left\{\begin{array}{l} 5\,(2CaO.Nb_2O_5) \\ 2Na_2O.Nb_2O_5 \\ Na_2\,F_6\,Zr \end{array}\right.$$

For I., if Ti : Zr = 2 : 1, the formula may be written

$$\left\{\begin{array}{l} 3\,(7CaO.Na_2O.4Nb_2O_5) \\ Na_2O.TiO_2 \\ Na_2\,F_6\,Ti \\ Na_2\,F_6\,Zr \end{array}\right.$$

As the fluorine and alkalies of pyrochlore and other minerals exist in the atomic ratio of 1 : 1, it is suggested by the author that in the action of alkaline fluorides as mineralising agents (in pneumatolitic processes and contact-metamorphism) the alkalies as well as the fluorine go to form the resulting minerals. L. J. S.

Rubies of Burma; their occurrence, origin and metamorphosis (C. B. Brown and J. W. Judd, *Proc. Roy. Soc.*, LVII, 387-394, 1895, and *Phil. Trans. Vol.* 187, A, 151-228, 1896). The famous

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ruby district of Upper Burma is situated 90 miles N.N.E. of Mandalay, the principal mining centre being Mogok. The gneissic rocks of the district are of intermediate chemical composition, including biotite-gneiss, biotite-granulite and rarely biotite-schist, hornblende being rare or absent, but garnet abundant. Interfoliated with these are more acid rocks, such as coarse pegmatites, aplites, quartzite, etc.; also more basic rocks, as pyroxene-gneiss and pyroxene-granulite, these passing into pyroxenites and amphibolites; and lastly bands of crystalline limestone. The acid rocks contain tourmaline, as in the adjacent rubellite district of Nyoungouk, where rubellite and indicolite occur; the basic rocks are rich in garnet, and the felspar (near anorthite) is often altered into scapolite, giving rise to scapolite-gneiss, etc. The limestones, in which alone the rubies and spinels occur, are more closely associated with the basic and ultra-basic rocks, these containing crystals of calcite, and as the amount of calcite increases, passing into the limestones; it being supposed that the limestones have been derived by the alteration of the felspar in the basic rocks. These lime felspars, having a great tendency to "werneritisation," give rise to a separation of calcium carbonate and hydrated aluminium silicates, the former being deposited as calcite and the latter as hydrated aluminium oxides (diaspore, gibbsite, &c.) which may be afterwards converted into anhydrous alumina. In the limestones, which are often highly micaceous, are found, graphite, pyrrhotite, corundum (ruby, sapphire, white sapphire, oriental topaz and oriental amethyst), spinel of various colours, rarely zircon, garnet, blue apatite, felspars (moonstone, etc.), quartz, micas (phlogopite, fuchsite, muscovite), hornblende, arfvedsonite, augite (sahlite and diopside), ægirine, enstatite (bronzite and hypersthene), wollastonite, lapis lazuli, fibrolite, scapolite, and also alteration products such as diaspore, margarite, chlorite, vermiculite and carbonates; there being an absence of fluorine and boron minerals.

The subsequent alteration of the rubies is seen as an inner zone of diaspore passing outwards into various hydrous aluminium silicates—margarites, clintonites, vermiculites, muscovites, kaolinites, etc.; these changes sometimes taking place in an irregular manner, but mostly along the primary and secondary solution planes (*Min. Mag.*, XI, 49), breaking the whole crystal up into an aggregate of simple forms. The associated spinel, quartz and felspar also exhibit external etching and internal chemical change. L. J. S.

Sylvite from Stassfurt. (W. Schimpff, *Zeits. f. Kryst.*, XXV, 92-3, 1895.) The sample examined is of interest as containing in negative

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crystals a relatively large proportion of hydrogen sulphide, which gas, on the solution of the salt, escapes under pressure with a crackling noise: this phenomenon is the same as that presented by the "knistersalz" variety of halite. The negative crystals present the same forms, $a(100)$ and $o(111)$, as the host. Under the microscope, as solution goes on, the walls of the cavities, when they become thin, are seen suddenly to give way, allowing a bubble of gas to escape. There are also larger cavities containing air and perhaps other gases; and others enclosing mother liquor, to which the impurities in the analysis are attributed. The hydrogen sulphide amounts to 3·01 per cent. by volume. Analysis gave

KCl	...	99·2890
NaCl	...	0·2424
$MgCl_2$	...	0·0890
$CaSO_4$	...	0·0730
H_2S	...	0·0023
Insoluble	...	0·1080
Loss on fusion		0·2847
		100·0331

L. J. S.

Celestite from Giershangen, Westphalia. (A. Arzruni and K. Thaddéeff, *Zeits. f. Kryst.*, XXV, 38-72, 1895.) The celestite from this locality is of interest as being chemically pure strontium sulphate, neither calcium nor barium being detected spectroscopically. The crystals are prismatic in the direction of the c axis, and are mostly colourless; $a : b : c = 0{\cdot}77962 : 1 : 1{\cdot}28533$. Sp. gr. 3·9665. $2V_{Na} = 50°46'$; $2E_{Na} = 87°44'$ The variations in the crystal angles of celestite are discussed in detail, and it is pointed out that this variation, which is usually considered (but not at all proved) to be due to the presence of calcium or barium, occurs, not only on crystals from different localities, but on crystals from the same specimen and even on the same crystal. A crystal from the above locality gave $mm = 75°4' - 76°14'$, another $75°21' - 76°38'$; the angles corresponding to the numerous published parameters show a greatest difference of $mm = 75°43' - 76°33'$ and $dd = 78°2' - 79°12'$. The cause of this variation is explained by the crystals being built up of smaller elements not quite in parallel position, but in fan-like arrangements about one or other zone-axis; the influence of any isomorphously contained calcium, &c. being quite subordinate. The variations in the optic axial angle ($2V_{Na} = 49°21' - 51°12'$, $2E = 84°43' - 90°4'$ of different authors) and of specific gravity are more likely to be due to the presence of calcium, etc.,

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though the not quite parallel growth will have some influence on the former; no connection between these variations and the composition has however been traced. From the published measurements the following constants for "normal" celestite are deduced, $a : b : c = 0{\cdot}78093 : 1 : 1{\cdot}28824$. $2\,V_{Na} = 50°34'$, $2E = 87°45'$. Sp. gr. 3·9665.

The existence of barytocelestite as a true isomorphous mixture is doubted. L. J. S.

Garnet simulating Jade (F. W. Clarke, *Am. J. Sc.*, L., 76, 1895). A waterworn pebble from 40 miles south of Los Angeles, California, closely resembled jade in being highly polished, very compact, and of an apple-green colour; analysis, however, showed it to be grossular garnet. Sp. gr. 3·485. L. J. S.

Cerussite with a superficial film of Galena (W. H. Hobbs, *Am. J. Sc.*, L, 121-3, 1895). Twinned prismatic crystals of cerussite from near Missoula, Montana, were partially coated with an extremely thin, glistening film of metallic lustre, the trace of sulphur and the excess of lead in the analysis showing this to consist of galena.

PbO	CO_2	Fe_2O_3,Al_2O_3	SiO_2	S	Total
80·83	15·51	0·55	2·15	tr.	99·04

The parts of the crystals so coated gave good reflections, but other parts did not. As this film of galena is not found on any of the associated minerals, it may be considered to be due to the alteration of the cerussite, probably by the action of hydrogen sulphide. A somewhat similar epimorph, but with the cerussite afterwards replaced by calcite, has been described by Blum. L. J. S.

Calaverite from Cripple Creek, Colorado (W. F. Hillebrand, *Am. J. Sc.*, L, 128-131, 1895). Tellurium has been previously known to occur in the ores of this district, partly in association with gold as gold-tellurium (sylvanite). Analyses of calaverite were made on the material collected from three mines, viz. Prince Albert Mine, I., Raven Mine, II., and C.O.D. mine, III.

	Te	Au	Ag	Insol.	Fe_2O_3	Fe	S	Total
I.	57·27	38·95	3·21	0·33	0·12	—	—	99·88
II.	47·69	33·93	1·47	5·80	—	5·41	6·17	100·47
III.	53·89	39·31	0·85	0·91	—	1·67	1·58	; also Mn, Ca, Mg, &c.

After deducting impurities (pyrites, etc.) these analyses reduce to the formula (Au, Ag) Te_2; the amount of silver in I. being very close to that

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in Genth's analyses. Selenium occurs in the district, but not in the calaverite. The mineral, which is of sparing occurrence, is of a pale bronze-yellow colour, the powder being greenish-gray. H = 3; Sp. gr. 9·00. In a note on the crystallography Penfield states the crystals to be prismatic in habit, the prism zone being deeply striated and irregular in cross section, while end faces are small and irregularly developed. The perfect cleavage of sylvanite and krennerite is absent, but there is a similarity in some of the angles to those of the former mineral. When placed in position to show the relation to sylvanite the prism zone is parallel to the *b* axis (of sylvanite); one crystal was then apparently a twin about 101 with the end faces 111 and 110, but other forms could not be referred to these axes. The system is given as probably asymmetric. L. J. S.

Marshite (Copper Iodide) from Broken Hill, N. S. Wales. (C. W. Marsh, *Journ. and Proc. Roy. Soc. N. S. Wales*, 1892, XXVI, 326-329). This new mineral occurs as small, translucent, reddish oil-brown crystals, of about $\frac{1}{24}''$ diam., on cerussite; the crystal form is given as tetragonal-hemihedral (compare, however, Miers, *Zeits. f. Kryst.* 1894, XXIV, 207, who gives it as cubic and tetrahedral). The lustre is resinous; streak orange-yellow; brittle, with sub-conchoidal fracture. When heated, violet fumes of iodine are given off; and it is soluble in hot nitric acid with evolution of iodine. Some of the earlier formed mineral has been altered to black copper oxide. Prof. A. Liversidge, in an accompanying note proposes the name marshite. L. J. S.

Willyamite, a new Broken Hill Mineral. (E. F. Pittman, *Journ. and Proc. Roy. Soc. N. S. W.*, XXVII, 366-368, 1893). This new mineral is found with dyscrasite in a calcite and chalybite vein. The crystal system is regular, and there is a perfect cubic cleavage; fracture uneven. Colour between tin-white and steel-grey, streak greyish-black; lustre metallic. H = $5\frac{1}{2}$; Sp. gr. 6·87. The formula CoS_2, NiS_2, $CoSb_2$, $NiSb_2$ corresponds to ullmannite with half the nickel replaced by cobalt. The mineral is named from Willyama, the official name of the Broken Hill township. L. J. S.

Alexjejewite. (V. Aleksyeev, *Verh. d. kais. russ. min. Ges.* [II], XXIX, 201-3, 1892; abstract in *Zeits. für Kryst.*, XXIV, 504, 1895). This new wax-like substance, from the Gov. Kaluga in Russia, resembles compact turf in appearance, it is soft and porous and of a white to brown

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colour. It contains, scattered in the interior, a compact light-yellow material having the same chemical and physical characters. Sp. gr. 0·950 (at 20° C.); melting point 64°–65°. Analysis gave: 75·5, C; 12·5, H; 12·0, O, and about 0·7 per cent. of ash. It is sparingly soluble in alcohol and benzene, and when heated gives off water and a white liquid of sp. gr. 0·786 (at 20°), boiling point 240°, and composition 83·4, C; 13·8, H. The name alexjejewite is proposed by A. Karnojitzky in the abstract quoted. L. J. S.

Epidote and Zoisite. The question of the relation between these two minerals has been reopened by E. Weinschenk in connection with an epidote very poor in iron from the Goslerwand in the Tirol (*Zeits. f. Kryst.* Vol. XXVI, p. 156, 1896). Like Brögger, he makes the crystallographic comparison by taking the ordinary c and b axes of zoisite as b and a respectively, and making the i-plane $(\bar{1}02)$ of epidote the base. The axial ratios then reduce for zoisite to

$$a : b : c = 2{\cdot}9158 : 1 : 1{\cdot}7900,$$

and for epidote to

$$a : b : c = 2{\cdot}8914 : 1 : 1{\cdot}8057,$$

with $\beta = 81°3'$, and the principal angles agree very closely for the two minerals. He combats Mallard's theory that zoisite is merely epidote with ultramicroscopic lamellar twinning parallel to (100). This may be reconciled with the crystallographic observations and the different cleavages of the two minerals, but not with their optical properties. The two silicates $H_2Ca_4Al_6Si_6O_{26}$ and $H_2Ca_4Fe_6Si_6O_{26}$ must be recognised as isodimorphous, their mixtures tending to crystallise in the rhombic or in the monoclinic system according as they are poor or rich in iron. The author's analyses are given below: I being epidote from the Rothenkopf, Zillerthal; II. the Goslerwand epidote, to which the name clinozoisite is given, agreeing in composition with many zoisites; III. the zoisite of the Gorner glacier, Zermatt; IV. the zoisite of the Kleinitz, near Prägraten, Tirol. The conclusion is that the epidotes form an isomorphous series with graduated physical and optical properties depending upon the percentage of iron oxide. Clinozoisite bears the same relation to the varieties richer in iron that enstatite does to bronzite and hypersthene. With increasing richness in iron the mean refractive index increases from 1·7195 to 1·7573; the birefringence from 0·0056 to 0·056; the colour and pleochroism become more marked; and the

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mineral passes from positive to negative, the angle 2V diminishing from 108° to 73°.

		I.	II.	III.	IV.
SiO_2	...	38·60	39·06	39·31	39·42
Al_2O_3	...	31·71	32·57	32·48	33·23
Cr_2O_3	...	—	—	—	0·41
Fe_2O_3	...	3·52	1·68	2·78	1·07
FeO	...	0·35	0·29	not det.	—
MnO	...	trace	trace	—	—
MgO	...	—	—	0·22	—
CaO	...	24·22	24·53	23·07	24·25
H_2O	...	1·95	2·01	2·54	2·11
		100·35	100·14	100·40	100·49
$\gamma - \alpha$	...	0·0105	0·0056	0·0088	—
Spec. gr.	...	3·3985	3·3720	3·3720	3·3410

A. H.

The grouping of the Garnets. E. Weinschenk has recently reviewed the mutual relations of the various members of the garnet group and the connection of their optical anomalies with their chemical composition and mode of occurrence (*Zeits. für Kryst.* Vol. XXV, p. 365, 1895). Taking the lime-alumina-garnet as a type, it is well known that the CaO may be more or less replaced by FeO, MnO, or MgO, the Al_2O_3 by Fe_2O_3, Cr_2O_3, and perhaps Ti_2O_3, and in rare cases the SiO_2 by TiO_2. These various replacements, however, are not all found to occur in any proportions, as in true isomorphism. The lime garnets are pretty sharply divided from those containing ferrous or manganous oxide or magnesia, while the members of the latter sub-group are chemically isomorphous with one another. Again, in the former sub-group are found all possible transitions between lime-alumina-, lime-iron-, lime-chrome-, and lime-titanium-garnet, while in the second sub-group alumina is always by far the dominant trivalent oxide. The only connecting link between the two sub-groups is between the lime and the manganese garnets: here intermediate varieties, though not common, occur in very different proportions. The modes of occurrence in nature of the several members of the garnet group are various: they are found either as rock-forming minerals or crystallised in fissures, &c.; and under the former head they are either primary constituents of igneous rocks or products of metamorphism.

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The author examines the occurrence and optical properties of the several members. The lime-garnets divide into those with and those without titanium, the former being frequently primary constituents of nepheline-syenites, phonolites, &c., while the latter are always secondary products. The titaniferous varieties are isotropic, the non-titaniferous birefringent and with polysynthetic structure. The manganese-garnets (spessartine) occur both as primary constituents of acid rock and as products of metamorphism. In the former case they are optically normal, in the latter abnormal. The ferrous garnets (almandine, &c.), whether as original rock constituents, as metamorphic minerals, or as the contents of druses and fissures, seem to be constantly isotropic. The magnesia-garnet, found always as a primary mineral in peridotites, &c., is also constantly isotropic.

Further data seem to be required before it can be decisively stated how far the optical anomalies of garnets are connected with chemical composition, and how far with the conditions of crystallisation. The peculiar polysynthetic structure, giving sectors with different optical orientation, seems to be confined to the non-titaniferous lime-garnets, and a portion of the manganese-garnets, often lime-bearing. On the other hand, the comparison of spessartines from different localities seems to indicate that garnets of closely similar composition may be isotropic when they are formed from an igneous magma, but present anomalies when they are produced by metamorphic or pneumatolytic processes. A. H.

Optical Characters of the Olivine Group (S. L. Penfield and E. H. Forbes, *Amer. Journ. Sci.* [4], I, 129-135, 1896; and *Zeits. f. Kryst* XXVI, 143, 1896). The following table shows that in the olivine group (excluding monticellite) as the amount of iron decreases there is a gradual increase in the value of the optic axial angle, which changes less rapidly at the magnesium end of the series; the value of β and the strength of double refraction decrease with the iron.

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	FeO per cent.	2 V_{Na} over a	β
Fayalite, Rockport, Mass.	68·1	49°50′	1·864
Hortonolite, Monroe, N.Y.	47·3	69°24′	1·791
Olivine, Auvergne	13·0	89°36′	1·692
,, Vesuvius	12·6	89°42′	
,, Hawaii	10·3	91°2′	
,, Egypt	9·2	91°19′	1·678
,, New Mexico	8·6	91°24′	
Forsterite, Vesuvius (Des Cloizeaux)	2?	93°50′	1·657

In the olivine group we always have $a=\mathfrak{c}$, $b=\mathfrak{a}$, $c=\mathfrak{b}$, but when there is less than about 12 per cent. of FeO the acute bisectrix is $\mathfrak{c}$ (except in monticellite), and with more iron it is $\mathfrak{a}$; in the former case the mineral is optically positive with $\rho < v$, and in the latter negative with $\rho > v$. In the paper, analyses and complete optical determinations are given of the fayalite of Rockport, the hortonolite of Monroe, and of the monticellite of Magnet Cove, Arkansas. L. J. S.

Salvadorite, a new copper-iron-vitriol (W. Herz, *Zeits. f. Kryst.*, XXVI, 16-18, 1896). This was found as an aggregate of bluish-green and blue crystals, cemented together by weathered iron vitriol, in the Salvador mine, Quetena, Calama, Chili. The somewhat indistinct and rounded crystals are mono-symmetric, with $b(010)$, and a prism with an angle of 48°16′; they are often twinned. The plane of symmetry is the direction of perfect cleavage, and is the plane of the optic axes. The extinction to the vertical axis is 52° for Na and 46½° for Tl light; optic axial angle 76° for Na and 87° for Tl about. Analysis of crystals gave:—

	FeO	CuO	SO_3	H_2O	Total
I. (green)	8·49	18·77	27·87	44·65	99·78
II. (blue)	8·59	17·57	28·16	44·31	99·63

Formula, $FeCu_2(SO_4)_3+21H_2O$. Salvadorite thus resembles pisanite in composition and crystalline system, but differs in the crystal habit and angle, in the cleavage, and in the angle of optical extinction; in pisanite the cleavage is $c(001)$, and $b(010)$ is the plane of the optic axes, but the extinction is about 74½° to the vertical axis. The two minerals may be dimorphous, or one may be an isomorphous mixture and the other a molecular compound, perhaps in salvadorite as $1(FeSO_4+7H_2O)+2(CuSO_4+7H_2O)$. L. J. S.

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Quiroguite (L. F. Navarro, *Anales Soc. Española Hist. Nat.*, XXIV, Actas 96-100, 1895). This mineral, named after F. Quiroga, occurs with anglesite, siderite, and pyrites at the mines San Andrés, Georgiana, Paraíso, &c. in the Sierra Almagrera, Spain. From the habit of the pyramidal crystals, the system is given as tetragonal, with the forms $a(111)$, $b(100)$, $m(001)$, $c(112)$?, $d(706)$? The measured angles are $111 : 11\bar{1} = 45°52'$, $111 : \bar{1}11 = 80°9'$, ab 49°34′, mc 54½°, md 45½°, cd 35°.[1] Schrauf, who has examined the crystals, suggests that they are probably only galena, in which eight faces of a triakisoctahedron are developed to the exclusion of the remainder, thus forming an acute square pyramid.[2] The basal cleavage is, however, stated to be more perfect than the two which are perpendicular to it; and thermal conductivity experiments are said to support the view that the mineral is tetragonal. Colour lead-grey; Sp. gr. 7·22; H=3. Analysis by F. Soria gave :—

Pb	Sb	Fe	S	Ag	Total
63·89	9·69	6·30	17·51	trace	97·39

From this is deduced $(PbS)_{30}$, $(Sb_2S_3)_4$, $(FeS)_{11}$, or, as pyrites was seen enclosed in the crystals, $(PbS)_{23}$, $(Sb_2S_3)_3$. L. J. S.

Phosphorescent Diamonds: Tiffanyite (G. F. Kunz, *Trans. New York Acad. Sci.*, XIV, 260, 1895). The various colours of diamonds are attributed to the presence of hydrocarbons; and the phosphorescence and fluorescence of certain diamonds are attributed to a bluish-white substance, which is undoubtedly a hydrocarbon, and for which the name tiffanyite is proposed. L. J. S.

Jadeite from "Tibet" (Max Bauer, *Neues Jahrb. f. Min.*, I, 85-95, 1896). Amongst jadeite pebbles from "Tibet in N. Himalayas" four colour varieties are distinguished: (1) snow-white with a tinge of lilac or violet; (2) white with a tinge of grey; (3) white with a greenish tinge; (4) sombre green with blue and grey shades, the green colour being here due to iron, and not to chromium, as in the emerald green spots of the white varieties. The last variety consists of interwoven needles and fibres,

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[1] From the angle $111 : 11\bar{1} = 45°52'$, the forms c and d are (335) and (305) respectively, and $a : c = 1 : 1·6712$. The last three angles, it will be noticed, are cubic angles.

[2] Schrauf gives the forms as (776), (887), (554), (111), and (221), and refers to his *Atlas der Krystall-formen*, taf. XXXV. fig. 14.

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sp. gr. 3·325, and contains veins of white, granular nepheline, of which an analysis is given, sp. gr. 2·628; with the nepheline is a small quantity of basic plagioclase, and enclosed in the grains are needles and prisms of jadeite. We, therefore, have here a jadeite-plagioclase-nepheline rock, in which the nepheline plays the part of the ground-mass, and in which, locally, the relative amounts of the constituents vary very considerably, the larger portion consisting mainly of jadeite, with here and there only a little of the felspar and nepheline. Two of the white varieties also show a little of this felspar and nepheline. Nepheline has previously only been recorded in igneous rocks, and its occurrence in a crystalline schist (viz. jadeite) is new. The low specific gravity given for some jadeites (sometimes below 3) is better explained by the presence of these minerals than by assuming uralitisation; for if the whole of the pyroxene were changed to hornblende, the specific gravity would still be greater than 3. This, together with isomorphous replacement, also explains the variations in chemical composition. L. J. S.

Etching of Calcite (A. Hamberg, *Geol. För. Förh.*, XVII, 53-73, 453-472, 1895; Abstr. in *Neues Jahrb. f. Min.*, I, Ref. 216-222, 1896). Plates of Iceland spar were cut in various definite directions, and the loss in weight per unit area (or sometimes the reduction in thickness) determined after they had been allowed to remain in hydrochloric acid. The solubility coefficient for any particular face, at any definite temperature, is defined as the amount of calcite in grams dissolved from 1 sq. cm. in one second by hydrochloric acid of specific gravity 1·09. If l_t be this coefficient at $t°$, then at $T°$ it is $l_T = l_t\,(1{\cdot}07473)^{(T-t)}$.

Face.	Coefficient at 0·4°.	Coefficient at 15°.	Coefficient at about 30°.	
OR (111)	0·000201	0·030551	0·00167	0·69
∞R ($2\bar{1}\bar{1}$)	0·000130	0·000335	0·00115	1·02
$\infty P2$ ($01\bar{1}$)	0·000125	0·000278	0·00093	1·00
$-2R$ ($\bar{1}11$)	0·000064	0·000149	0·00061	0·67
$+R$(100)	0·000054	0·000159	0·00072	0·94
$+4R$ ($3\bar{1}\bar{1}$)	0·000140	0·000528	0·00153	—
$-\frac{1}{2}R$ (101)	0·000213	0·000580	0·00164	0·78
$+R2$ ($30\bar{1}$)	0·000237	0·000670	0·00179	—
$+2R$ ($5\bar{1}\bar{1}$)	0·000236	0·000726	0·00197	1·17

The results obtained are the more accurate when solution takes place more quickly. On the easily soluble faces solution proceeds regularly

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without the formation of etch figures; but on (100) and ($\bar{1}11$) etch figures are developed, solution having here gone on in the direction of other planes. Confirmatory results were obtained with calcite cylinders cut in various zones.

With more dilute acid, the same maxima and minima occur, but the difference between them is less. Numerous measurements are given, showing the effects of the presence of calcium chloride or sugar with the hydrochloric acid. Acetic acid was also used. The last column in the above table gives the relative solubilities when water containing carbon dioxide under a pressure of six atmospheres is used; here sharp etch figures are developed on the basal plane. L. J. S.

An artificial form of Silica (F. Rinne, *Neues Jahrb. f. Min.*, I, 139-148, 1896). The action of acids on heulandite and the resulting changes in the optical characters are described. When the mineral is placed in anhydrous sulphuric acid the effect is the same as heating to 150°, this having been previously described by the author. Dilute sulphuric acid, or hydrochloric acid, however, completely decomposes the mineral, leaving silica with the form of the heulandite cleavage flakes. This silica shows a negative bisectrix perpendicular to the plate, the magnitude of the optic axial angle varying in different fields; the double refraction is fairly strong. When heated to redness, there is a loss of about 8·8 per cent. of water, but no change in the optical characters. The specific gravity of 2·143 is near to that of tridymite and of cristobalite, but the optical characters differ. L. J. S.

Caswellite, an altered Biotite (A. H. Chester, *Trans. New York Acad. Sci.* XIII, 181-183, 1894). This new mineral from Trotter Mine, Franklin Furnace, N.J., which has the characters of a clintonite, is of a flesh- to light copper-red colour; it has a bronzy lustre, a micaceous structure, and is brittle; H = 2·5-3; sp. gr. 3·54. It is associated with massive yellow garnet (polyadelphite), granular rhodonite, and somewhat altered, dark brown biotite, into the latter of which there is a gradual passage. It is completely decomposed by hydrochloric acid, with separation of gelatinous silica; the mean of two analyses is—

Loss on ignition	SiO_2	Fe_2O_3	Al_2O_3	Mn_2O_3	CaO	MgO	Total
4·64	38·74	6·85	6·58	15·96	22·30	2·52	100·58

This gives approximately the ratio $SiO_2 : R_2O_3 : RO : H_2O = 6 : 2 : 5 : 2·5$. The mineral is very feebly doubly refracting, shows no pleochroism, and

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has a larger optic axial angle than the biotite from which it has been derived. Unaltered biotite from another part of the mine contains a considerable amount of potassium, much magnesium, and little or no calcium, and it is supposed that the caswellite has been derived by the local action of water, containing manganese and calcium, on this biotite, the alkalies having been carried away. L. J. S.

Precious Opal from White Cliffs, N.S.W. (T. Cooksey, *Records Australian Museum*, II., 111, 1896). The crystalline calcite, which has replaced the calcium carbonate of shells in a ferruginous sandstone at White Cliffs, N.S.W., has itself been replaced by precious opal, which reproduces the cleavages of the calcite. These flat and regular cracks in the opal give rise to the play of colours, that from conchoidal cracks and fractures being subordinate. L. J. S.

Hastingsite, a new Alkali Hornblende (F. D. Adams and B. J. Harrington, *Amer. Journ. Sci.*, [4], I, 210-218, 1896). One of the two hornblendes occurring in the nepheline-syenite of Dungannon, Hastings Co., Ontario, which was in a previous paper mentioned as being allied to arfvedsonite (Abstr. XI, 46), is here described in detail. It has a small optic axial angle (30° or 45°), the plane of the optic axes being (010), and the strong dispersion $\rho > \nu$; the extinction angle is large ($c : c' = 30°$), the double refraction low, and the pleochroism *a* yellowish-green, *b* and *c* deep bluish-green. The chemical analysis is given under I; calculating the titanium with the silicon, this gives the orthosilicate formula $(R_2', R'')_3R_2''Si_3O_{12}$, which is the same as that given by Scharizer for "syntagmatite" in his theory of the composition of aluminous amphiboles. Hornblendes similar to the above occur in the nepheline-syenite at Montreal and at Umptek in the Kola Peninsula.

	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	CaO
I.....	34·184	1·527	11·517	12·621	21·979	0·629	9·867
II.....	36·604	1·078	9·771	15·996	3·852	1·301	29·306

	MgO	K_2O	Na_2O	Loss on ignition	Total	Sp. gr.
I.....	1·353	2·286	3·290	0·348	99·601	3·433
II.....	1·384	—	—	0·285	99·577	3·739

Under II. is the analysis of a *titaniferous andradite*, which occurs as brown, isotropic grains in the Dungannon rock; calculating the titanium as Ti_2O_3, the garnet formula is deduced. The mineral encloses calcite

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(apparently not secondary), hornblende, pyrites, iron ore and nepheline. Similar garnets occur at Montreal, Stokö and Alnö. L. J. S.

Optical Properties of Epidote (E. H. Forbes, *Amer. Journ. Sci.*, [4], I, 26-30, 1896; and *Zeits. f. Kryst.*, XXVI, 138, 1896). The grey epidote of Huntington, Mass., is described in detail, and optical determinations are given of green epidote from the Zillerthal. The results are compared with those obtained by Klein (1879) for the Untersulzbachthal crystals, showing that there is a gradual change in the magnitude of the optical constants (for sodium light) with the amount of iron :—

	Fe_2O_3 per cent.	α	β	γ	$\gamma-\alpha$	2 V over a
(Klein)	14·0	1·7305	1·7540	1·7677(r)	0·0372	73°39′
Zillerthal	6·97	1·720	1·7245	1·7344	0·0144	87°46′
Huntington	5·67	1·714	1·716	1·724	0·010	90°32′

Here, with the decrease of iron, there is an increase in the optic axial angle, until for the Huntington mineral the sign has changed to positive with $\rho < v$. L. J. S.

Method for the determination of the refractive power of a mineral in sections. C. Viola (*Tscherm. Min. Mitth.* XVI. (ii.) 150-4) bases his method on the mode of observation devised by Becke for distinguishing between the more highly refractive and the less refractive minerals in sections. The Becke process consists in regulating the illumination by means of an iris diaphragm above or beneath the polariser, and raising the objective, when a bright strip will be seen on the side of the more highly refractive mineral, and a dark strip on the side of the less refractive mineral. The excess of illumination on the side of the more highly refractive mineral is of course due to the light which has been totally reflected at the boundary. For the eye to be able to appreciate the effect, a certain limit of illumination (obtained by gradually closing the iris diaphragm) is necessary. A simple calculation shows that at this limit of illumination the difference of the refractive indices of two minerals in contact in a section is proportional to the square of the aperture of the iris-diaphragm,

$$\text{Or, } n_2 - n_1 = \lambda D^2.$$

The constant λ is determined by means of minerals of which the refractive indices are known.

By means of this formula, given the refractive index of one mineral (or

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of the Canada balsam in which a mineral is mounted), that of the other is obtained by measuring *D*.

The author states that with practice the method gives results correct to the third decimal place. G. T. P.

The Elæolite-Syenite of the Serra de Monchique (K. von Kraatz-Koschlau and V. Hackman, *Tscherm. Min. Mitth.* XVI. 1896, 197-307. One plate and map). In this paper is given a very detailed account of the well-known elæolite-syenite massive of Monchique, the dyke rocks connected with it, and its contact effects on the grauwacke and Culm-slates through which it was erupted.

The whole massive, about 60 square kilometres in extent, may be roughly divided into two main types, viz. the normal elæolite-syenite of Picota and the syenite of Foia, much poorer in elæolite, and in many respects very similar to the pulaskite from the Fourche Mountains, Arkansas, described by J. F. Williams (*Ann. Rep. Geol. Survey of Arkansas for 1890*). The coarse-grained elæolite syenite of Picota consists mainly of gray felspar (soda-orthoclase with microcline and albite) and reddish-brown nephelite. Compared with these minerals the darker ferro-magnesian minerals only occur in small amount. These consist of diopside with ægyrine-augite border, biotite and arfvedsonite-like hornblende. Other constituents are sphene, sodalite, fluor (in dark violet grains), lithia-mica, rutile, and apatite; and amongst the decomposition products, cancrinite, zeolites, calcite and muscovite. Låvenite in minute grains and prisms, showing strong pleochroism, occurred very sparingly. In chemical composition the rock approaches very closely the elæolite-syenite of Pouzac, described by Lacroix. The elæolite-syenite of the Foia differs from the Picota mass in its slight content of nephelite; and, although there is probably no sharp boundary line between the two rocks, the Foia mass, from its generally finer grain, appears to have consolidated at a different depth from the Picota.

Near the village of Monchique the Foia rock is most like the Picota, but even there the felspar (mostly moirée-microcline of Brögger) is considerably in excess of the nephelite. This rock passes quickly into one very poor in nephelite, and macroscopically very like the Pulaskites (so-called blue granites) of the Fourche Mountains.

In both the Picota and the Foia masses occur irregular patches of fine-grained elæolite-syenite. On the way from Monchique to Caldas were found considerable masses of an interesting basic rock, which is described as a product of magmatic differentiation due to the contact with the slates.

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The rock is very similar to the Teschenite of Moravia, with the difference that it contains nephelite instead of analcite. Between it and the elæolite-syenite there is a quick passage, but no sharp boundary.

In the neighbourhood of the contact the elæolite-syenite was found to undergo the following modification:—The grain changes quickly; the rocks becoming first medium or fine-grained with porphyritic constituents, and then uniformly fine-grained up to almost dense. Important changes also occur in the mineral composition. Ægyrine-augite without zonal banding or pure ægyrine takes the place of the ægyrine-augite with zonal banding, but often the pyroxene disappears altogether, and biotite becomes the only coloured silicate. The ores become more plentiful than in the normal syenite, and låvenite, which only occurs exceptionally in the main mass, is generally present on the contact. Confined to the neighbourhood of the contact is also the mineral which was first observed by van Werveke, and it is referred to the pyrrhite of the sanidinite of Sao Miguel.

The dykes which cut the elæolite-syenite are fairly numerous, but generally small, rarely exceeding 2 metres in width. The rocks which form them belong to a variety of types, viz. bostonite-porphyry, tinguaite, nephelite-syenite-porphyry, camptonitic tinguaite and camptonitic monchiquite rocks. Amongst the tinguaites on the south slope of the Picota occurs a peculiar glassy rock to which the authors, on account of its chemical composition, give the name of leucite-tinguaite-vitrophyre, although no leucite could be detected in the rock. The tinguaites are divided into green ægyrine-tinguaites (confined to the Foia) and dark gray ægyrine-mica tinguaites (almost confined to the Picota). A camptonitic tinguaite found at Corte Grande forms a passage to the basic group of dyke-rocks, viz. the camptonitic monchiquites. To the latter group belong rocks which the authors describe under the names of nepheline-tephrite, nepheline-basanite, amphibole-monchiquite, amphibole-biotite-camptonite, fourchite and ouachitite. The analcite found in some of these rocks they regard as pseudomorphous after leucite. [L. V. Pirsson, however, has recently brought forward proofs to show that the so-called glassy base of the monchiquites really consists of analcite, and that the analcite in these rocks should be regarded as a primary constituent (*Journ. Geol.* IV. 1896, No. 6). G. T. P.]

The elæolite-syenite massive is surrounded by a contact zone of metamorphosed grauwackes and clay-slates. These metamorphic rocks consist of quartzose grauwacke, black hornfels and knotted clay-slates. On the borders of the massive were also found metamorphosed eruptive rocks, diabase-hornfels and a cordierite-mica-hornfels. G. T. P.

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Elæolite-syenites, phonolites, etc., in Texas. The researches of the Geological Survey of Texas have recently added another to the known districts of nepheline-bearing rocks on the east side of the Rocky Mountains. A. Osann contributes an account of some of these rocks from the Apache or Davis Mountains in the western (trans-Pecos) portion of the State (*Tscherm. Min. u. Petr. Mitth.*, Vol. XV, p. 394). They include plutonic, dyke, and volcanic rocks. True elæolite syenites occur in the Mount Ord range, where they pass through a fine-grained porphyritic modification into a marginal phonolitic facies.

The normal rock consists of felspars, pyroxenes, hornblende, biotite, elæolite, låvenite, magnetite, and apatite. The felspars are partly orthoclase, partly an acid plagioclase, often with microperthitic intergrowths. The pyroxene is chiefly a green augite, passing at the margin of a crystal into ægirine-augite and true ægirine. The elæolite is now wholly replaced by zeolites. Låvenite is constantly present, and is recognised by its high refringence and birefringence and its pleochroism: α and β faint yellow, γ deep wine-yellow; extinction-angle $ac = 16°$ to $18°$. Zircon, on the other hand, is absent.

In the fine-grained porphyritic variety, elæolite and sodalite become prominent constituents, biotite is less frequent, and ægirine increases in quantity at the expense of augite. The felspars become smaller (except the porphyritic crystals), and show some parallel orientation. In the phonolitic facies fresh nepheline is abundant, mica is wanting, and the augite and hornblende are completely replaced by ægirine-augite, ægirine, and arfvedsonite. A mineral identified with ænigmatite is also very frequent. It is transparent only in very thin slices, giving a brown colour with pleochroism: α brown, β and γ "dark red-brown-carmine." This and the other coloured constituents tend to form fibrous aggregates or patches in the ground-mass of the rock. Eudialyte, or an allied mineral, is found in some specimens.

In the Saw-tooth Mountains, to the west of the Apache group, occurs a mass of syenite, passing at its margin into fine-textured porphyritic varieties. The syenite consists of orthoclase and microperthite, augite, brown hornblende, a little biotite, zircon, sphene, iron-ores and abundant apatite. The porphyritic rocks are interesting for the habit of the large felspars, which agree with those of the Norwegian rhomb-porphyries in having the prism and basal planes predominating. In optical properties also they correspond, and they contain soda as well as potash. An analysis of the syenite given below (I.) is probably too low in alumina and too high in alkalies, but gives a general idea of the composition of the rock.

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An ægirine-syenite from Mosquez Cañon and an elæolite-syenite from Paisano Pass are also described.

The dyke-rocks associated with the above plutonic masses include the tinguaite and bostonite groups found in like association in other districts and a third, more acid, to which the name "paisanite" is given. The tinguaites are divided into three sub-groups; normal tinguaite (with

	I.	II.		III.
SiO_2	59·48	73·35		71·10
TiO_2	0·17	—		0·57
Al_2O_3	13·46	14·38		11·39
Fe_2O_3	6·71	1·96		5·33
FeO		0·34		
MgO	1·64	0·09		1·54
CaO	1·83	0·26		0·08
Na_2O	11·67	4·33		3·95
K_2O	6.03	5·66		6·37
H_2O	0·20	—		0·44
			P_2O_5	0·05
	101·19	100·37		100·82

nepheline), mica-bearing tinguaite, and tinguaite without nepheline. The bostonites, very poor in coloured minerals and in quartz, consisting mainly of felspar, include orthophyric and trachytic types. The paisanites consist essentially of quartz, felspar, and riebeckite. The last occurs in ragged patches with deep blue colour and pleochroism: α dark blue, β rather paler grey-blue, γ pale green with a yellowish tone. A chemical analysis of a typical paisanite from Mosquez Cañon gave the result II, which shows some resemblance to Norwegian dyke-rocks described by Brögger (grorudite, &c.; see p. 115 of this volume). From these it differs mineralogically in having the amphibole-mineral riebeckite instead of ægirine, and also in the mode of occurrence of this coloured mineral. The analysis corresponds to riebeckite 6 per cent., orthoclase 35, albite 32, and quartz 27.

The volcanic rocks of the district include basalts, liparites (rhyolites), and phonolites. At one locality, Limpia Creek, flows of the three are seen to overlie one another in this order. The rocks referred to liparite contain porphyritic crystals of a peculiar sanidine (rich in soda; sp. gr. 2·582) in a ground-mass of quartz and felspar. The only coloured mineral is a little pale green pyroxene, apparently ægirine. A liparite from Fort Davis gave the figures under Column III.

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The phonolites are rich in nepheline, which occurs partly in porphyritic crystals in a ground-mass of variable texture. Ferromagnesian minerals are also abundant. The pyroxenes are represented by augite, ægirine-augite, and ægirine. The first, often bordered by the others, is found chiefly in the more coarse-grained rocks, in the finer ones the border of soda-bearing pyroxene is increased at the expense of the augite-nucleus. Of the amphibole minerals the coarser rocks contain chiefly a brown hornblende (a = pale brown to yellow-brown, β = dark brown, γ = dark green to green-brown; extinction angle *ca* 15°). This is replaced in the finer textured rocks by a blue amphibole like the catoforite of Brögger, *l.c.* (a = dark green-blue to pure steel-blue, β = dark brown-grey, γ = faint yellow-brown; extinction angle *ca* over 20°). Both minerals occur in fibrous aggregates, and ænigmatite is found in the same habit.

The age of all these rocks is not known, further than that they are post-carboniferous. The "consanguinity" of the whole series is very clearly indicated, and the numerous points of resemblance between these rocks and those of the Christiania basin are of special interest. A. H.

Nepheline-syenite of Alnö (A. G. Högbom, *Geol. Fören. Stockholm Förhandl.* XVII. 2 and 3, 1895). The nepheline syenite of Alnö and rocks related to it are confined to the north-east and north part of the island. The most interesting feature of this syenite region from the theoretical point of view is the remarkable way in which a limestone, rich in minerals, is associated with the syenite. This limestone has not the characters of a metamorphosed sedimentary rock. The minerals which it contains have been formed at the expense of the syenite magma, and where these fail the rock consists of almost chemically pure calcium carbonate. Whatever may be the origin of this limestone, all the author's observations tend to the conclusion that it has been fused and taken up by the magma without decomposition, and that in the solidification calcite has crystallised out of the magma in precisely the same way as the other minerals. The numerous occurrences of primary calcite in the eruptive rocks of this region, the pegmatitic intergrowth of calcite with nepheline, ægirine, felspar, &c., all help to support this idea. The possibility of the existence of calcium carbonate in the magma may have been due to the slight acidity of the nepheline-syenite magma, which offered no excess of silica for the decomposition of the calcite, and to the high pressure under which solidification of the rock took place. The author is, therefore, inclined to regard this limestone, so closely connected with the nepheline-syenite and so rich in syenite minerals, as a product of the

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differentiation of the magma, rich in lime and carbonic acid, in the same way as the other differentiated rocks of this region.

The contact phenomena between the nepheline-syenite and the surrounding gneiss also offer some points of interest. Although there can be no real passage of one of these rocks into the other, yet the line of junction is often difficult to fix. Against the gneiss the syenite loses its nepheline, becomes somewhat schistose, and, by the addition of biotite, gains a very gneiss-like appearance. On the other hand, the gneiss along the junction is also altered. The amount of quartz diminishes, the gneiss minerals are corroded or re-absorbed to give place to others, amongst which are many of the syenite minerals. As regards the age of the nepheline-syenite, all that can be said, in the absence throughout the whole region of younger sedimentary rocks, is that the eruption took place in post-Archæan time, since the rocks show no evidence of dynamic effects such as everywhere characterise the Swedish Archæan rocks.

Connected with the mass of nepheline syenite are numerous dyke rocks. Many of these dykes are of melilite-basalt (alnoite) and of red nepheline-syenite or tinguaite; but there is a remarkable group consisting principally of calcite and zeolites without dark minerals, which the author considers represents the dyke form of the massive limestone just as the alnoite and tinguaite may be regarded as the petrographical equivalents of the basic and acid massive rocks which have resulted from the differentiation of the magma. The author gives detailed and exhaustive descriptions of all the rocks of the district. As regards the nepheline syenite, magmatic differentiation has given rise to a number of differentiation products, to which, however, the author, with commendable restraint, has refrained from giving distinctive names. In a coloured plate the approximate mineral composition (as determined by areal measurements in sections under the microscope) of eight of these differentiation products is graphically represented. They range from a normal nepheline-syenite consisting of orthoclase with nepheline and pyroxene (No. I.) to a very basic rock (No. VIII.), consisting mainly of olivine and magnetite, very similar to the magnetite-olivenites of the hyperite rocks. Besides these differentiation products there is the zone of acid nepheline-syenite along the contact with the gneiss. The felspar of these nepheline-syenites is almost exclusively orthoclase which like the sanidine of some eruptive rocks contains from 1 to 2 per cent. of barium oxide.

Of the more basic differentiation products those which are rich in apatite approximate to the Jacupirangite of Brazil described by O. A. Derby. G. T. P.

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Ancient acid lavas in Massachusetts. J. Sears (*Bull. Mus. Comp. Zool. Harvard*, Vol. XVI, No. 9), has described an interesting rock from Marblehead Neck. It had been already shown by Wadsworth to be an ancient lava-flow, and it now appears to be comparable with the "Keratophyre" of the German petrologists. Porphyritic crystals of felspar are found to be anorthoclase, with specific gravity 2·570 – 2·572 and composition expressed by I. (Analysis by T. Chatard.)

	I.	II.	III.
H_2O at 110° C.	0·04	0·91	1·06
H_2O at red heat	0·37	1·28	
SiO_2 ...	65·66	70·23	73·00
TiO_2 ? ...	—	0·03	—
P_2O_5 ...	—	0·06	—
Al_2O_3 ...	20·05	15·00	15·61
Fe_2O_3 ...	traces	1·99	—
FeO ...	traces	—	1·95
MnO ..	0·13	0·24	—
CaO ...	0·67	0·33	0·79
MgO ...	0·18	0·38	—
K_2O ...	6·98	4·99	0·88
Na_2O ...	6·56	4·98	4·95

The ground-mass consists of minute lath-shaped felspars with quartz, etc., and the bulk analysis of the rock is given by II. A. H.

Ancient acid lavas in Wisconsin. Recent researches have detected in many parts of the United States volcanic rocks of Palæozoic and pre-Palæozoic age agreeing in many respects with those already known in England and Wales. S. Weidman has described some interesting examples associated with the Upper Huronian quartzites of the Baraboo Bluffs in Wisconsin. (*Bull. Univ. Wis., Sci. Ser.*, Vol. I, p. 35, 1895.) Like the Massachusetts rocks noticed above, these are acid lavas with a relatively high content of soda, and may be described as old soda-rhyolites. The author follows German usage in naming them quartz-keratophyre. The porphyritic elements are soda-orthoclase and soda-plagioclase, quartz being rare and deeply corroded: ilmenite, biotite, zircon and magnetite also occur. The ground-mass is a holocrystalline aggregate of quartz and felspar, showing in different examples fluxion, micropœcilitic, and spherulitic structures. A bulk-analysis by C. F. Austin gave the result quoted under Column III. above (with 0·76 of SO_3): specific

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gravity, 2·63. Volcanic breccia is in places associated with the lava. Another interesting feature is the conversion of the latter into a sericite-schist by crushing near its contact with the quartzite. A. H.

Ancient lavas and dyke-rocks from New Brunswick. W. D. Matthew contributes to the growing literature of the pre-Cambrian volcanic rocks of the eastern parts of North America an account of the lavas and associated dykes of the so called Huronian in southern New Brunswick. The prevalent type, termed by the author felsite-porphyry, is shown to be identical in essential characters with recent rhyolites, the characteristic structures of the rocks, such as the perlitic, trichitic, and spherulitic, being preserved in various examples in spite of devitrification and other changes. Excepting two occurrences, porphyritic quartz is rare, and the ferro-magnesian silicates are scarcely represented. Fragmental rocks of acid constitution are also abundant, and some contain what are regarded as volcanic bombs. Basic lavas and tuffs are also found, and some lavas of strongly porphyritic character.

A soda-granite of granophyric tendency is also described. It contains apparently anorthoclase, and its coloured constituents are augite and brown hornblende. A bulk-analysis shows the similarity of the rock to that described by U. S. Grant, from Kekequabic Lake, Minnesota.

The dyke-rocks include diorite-porphyrite and camptonite, diabase, and augite-porphyrite. (*Trans. N. Y. Acad. Sci.*, 1894, p. 185.) A. H.

Eruptive rocks from Montana. G. P. Merrill has recently described a collection of rocks from Gallatin, Jefferson, and Madison Counties, Montana, several of which possess special interest (*Proc. U. S. National Mus.* Vol. XVII, p. 637, 1895.) One from near Bozeman, provisionally referred to the basalts, is a compact dark rock, thickly studded with rounded olivines up to 5mm. and smaller green augites. The groundmass is clear and colourless in thin slices, but seems to have little or no glassy base, consisting essentially of imperfect radial spherulitic aggregates, such as are more familiar in acid rocks. The augite proves to be a chrome-bearing diopside (Analysis I. by Eakins). The bulk-analysis of the rock (II. by Chatard) is remarkable for its high percentage of magnesia and other peculiarities: the specific gravity is 2·86.

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	I.	II.	III.	IV.	V.	VI.
SiO_2	52·50	46·90	48·95	46·13	46·35	51·83
TiO_2	—	0·41	0·81	0·73	—	0·29
Al_2O_3	2·26	10·17	5·69	4·69	16·41	7·98
Cr_2O_3	1·07	0·38	0·05	0·04	—	0·31
Fe_2O_3	2·05	1·22	1·20	0·73	9·91	1·48
FeO	2·47	5·17	12·11	16·87	not det.	8·28
MnO	trace	0·10	0·08	trace	—	trace
MgO	17·11	20·98	23·49	25·17	18·72	24·10
CaO	21·70	6·20	5·33	4·41	6·14	5·26
Na_2O	0·35	1·16	1·58	0·08	—	0·35
K_2O	0·07	2·04	0·79	trace	—	0·06
H_2O	0·64	1·04 at 120° C. / 4·38 at red heat	0·18	1·38	3·01 (ign.)	0·29 (ign.)
P_2O_5	—	0·44	0·12	0·07	—	0·09
	100·22	100·54	100·54	100·63	100·54	100·43

A hornblende-andesite from near Fort Ellis is noteworthy for the abundance of corroded crystals of brick red dichroic apatite, up to 0·6mm.

A peridotite (wehrlite) from near Red Bluff is a coarse or fine-textured crystalline aggregate of pale green diallage, deep reddish-brown mica, and olivine: III. is a bulk-analysis by Eakins (with NiO=0·16 and BaO trace): specific gravity 3·37. A hornblende picrite from North Meadow Creek is a holocrystalline aggregate ef hornblende (light green to colourless in slices), abundant olivine, pleonaste, iron-ores, and occasional hypersthene. Its specific gravity is 3·35, and an analysis by Eakins gave the figures in column IV. with NiO=0·09, BaO trace, and S=0·24. A peridotite (saxonite) from the same district shews under the microscope a dense ground-mass of granular colourless rhombic pyroxene and pale brown hornblende, with a few olivines, iron-oxides, and dull green pleonaste, enclosing phenocrysts of bronzite, etc. An analysis by Merrill gave the result V. the specific gravity being 3·21.

A rock from between Meadow and Granite Creeks is provisionally placed under pyroxenite, consisting of hypersthene and hornblende, and giving the bulk-analysis VI. (Eakins), with NiO=0·11. The hornblende gave the composition VII. (Merrill). A similar rock differed in containing abundant deep green pleonaste which gave the analysis VIII. (Eakins) with specific gravity 3·89. A pyroxenite of the websterite type, from near Jackass Creek, shews in thin slices a fine granular aggregate of light green diallage and colourless enstatite, with folia of brown mica, and

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occasional areas of lime-soda-felspar, indicating a transition to the gabbro type. The rock gave the composition in column IX. (Merrill): specific gravity 3·30.

	VII.	VIII.	IX.	X.	XI.
SiO_2	46·14	0·55	54·12	50·82	54·15
TiO_2	—	—	—	0·59	not det.
Al_2O_3	17·07	62·09	7·91	11·44	18·92
Cr_2O_3	—	2·62	—	0·03	—
Fe_2O_3	8·45	2·10	not det.	0·25	} 6·79
FeO	not det.	17·56	12·87	8.94	}
MnO	—	trace	present	0·19	not det.
MgO	15·01	15·61	16·64	14·01	1·90
CaO	11·70	0·16	6·21	8·14	3·72
Na_2O	1·11	—	0·44	1·79	5·47
K_2O	0·10	—	1·19	3·45	8·44
H_2O	—	—	—	0·58 (ign.)	not det.
P_2O_5	—	—	—	0·20	not det.
	99·58	100·69	99·38	100·49	99·81

A peculiar type of lamprophyre is described from between South Boulder and Antelope Creeks. It contains abundant perfectly formed green augites and olivine in an apparently holocrystalline ground-mass of felspar with abundant brown mica, etc. Analysis X. with BaO=0·06, was made by Eakins, and the specific gravity was found to be 2·96. This rock overlies a micaceous syenite with nearly six per cent. of sodalite and a composition represented by XI. with Cl=0·42 (Merrill). This analysis agrees closely with that of Lindgren's sodalite-syenite from Square Butte, Montana. A. H.

Leucite-bearing rocks in the Lipari Isles. H. Bäckström has recently drawn attention to a hitherto unrecognised type of rock occurring among the varied lavas of the Lipari group of volcanoes. It is represented by the rocks of Vulcanello, the latest member of the group, formed by an eruption in the year 187 B.C. Petrographically it is a leucite-basanite of a type poor in olivine and containing orthoclase. The larger elements are crystals of augite, labradorite, olivine and magnetite while the ground-mass is a holocrystalline fine-grained mass of felspar, pyroxene, and a variable amount of leucite. The lath-shaped felspars are partly orthoclase, partly oligoclase: the pyroxene is of the same kind as that of

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the earlier generation. A chemical analysis of one of the rocks gave the result—

SiO_2	Al_2O_3 & Fe_2O_3	MgO	CaO	Na_2O	K_2O	Total.
51·38	26·35	6·02	9·09	4·76	3·33	100·93

The author remarks that a rock of such composition consolidated under intrusive, instead of effusive conditions, would be a lamprophyre rich in mica (*Geol. Fören. i Stockholm Förhand.* Vol. XVIII, p. 155, 1896). A. H.

Metamorphosed gabbros, etc., in the Zermatt district. Saussurite-gabbros and allied types are well known, chiefly in the form of boulders in the Visp and Saas Valleys, and some of them have been described by Bonney and others. A more complete study of the rocks and of their mutual relations is embodied in an "Inaugural-dissertation" by R. W. Schäfer (*Tscherm. Min. u. Petr. Mitth.*, Vol. XVI. 1895). After a general geological account of the district, including the Allalingrat and neighbouring ridges rising above the glaciers, the author proceeds to describe the rocks under the two main divisions of granular and foliated ('flasrig').

He begins with a coarse-textured olivine-gabbro found only as boulders in the moraines in the Allalin glacier. This consists of labradorite (with secondary interpositions of amphibole), rounded grains of fresh olivine, and brown diallage (colourless in thin slices), without apatite or iron-ore. Between olivine and felspar is always interposed a narrow border, consisting of little crystals, partly of amphibole, set normally to the boundary. The olivine and diallage are together about equal in quantity to the felspar, but their relative proportions vary, and the rock thus graduates on the one hand into forellenstein, on the other into a gabbro with only accessory olivine.

Resembling the preceding in grain and structure is the saussurite-gabbro, noticed by several authors; and various intermediate examples illustrate the derivation of this rock from the other. The felspar is replaced here by a hard, compact, extremely fine-grained "saussurite" aggregate, consisting of little prisms of zoisite, with irregular patches of amphibole, and locally talc. The specific gravity of the aggregate was found to be 3·274. The diallage of the olivine-gabbro is pseudomorphed by amphibole, either as deep green actinolite or as grass-green smaragdite rich in rutiles. The olivine is represented by round patches consisting of talc, actinolite and garnet, the last forming the peripheral

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part towards the saussurite-aggregates. An interesting point is the occurrence in the talc of little irregular black flakes of ottrelite: pleochroism in sections, α = olive-green, β = plum-colour, γ = yellowish. The saussurite-gabbro shows varieties corresponding with those of the normal rock, as indicated by the dwindling or disappearance of the several constituents, viz. saussurite, smaragdite, and talc-actinolite-garnet-aggregate. Another variety, from the Allalingrat is a saussurite-diallage-rock with red rutile-grains, garnet, and pyrites; the garnet being richly enclosed in the diallage.

Another rock, from the Hinterallalingrat, consists of amphibole and saussurite with garnet, pyrites and apatite. The amphibole is of specific gravity 3·17, gives the flame-reaction of sodium, and has the pleochroism-scheme γ = grey-blue, β = grass-green, α = yellowish. It thus shows an approach to glaucophane, though its extinction angle (14° in a cleavage-flake) is too high for that mineral. The saussurite of this rock consists mainly of new-formed felspar in clear untwinned grains, probably albite. In the moraine of the Allalin glacier occur true glaucophane-bearing eclogites. One consists of amphibole and pyroxene (intergrown), with abundant garnet and accessory minerals. The amphibole gives a sodium-reaction, and its pleochroism is γ = deep sky-blue, β = olive-green, and α = yellow-green. The pyroxene is an omphacite. The eclogite passes into an amphibole-epidote-rock.

Between the granular gabbros and the well foliated rocks ('Grünschiefer') there is a gradual transition through partly foliated and banded ('flaser') gabbros. A type common among the erratics of the Saas valley, and seen in place on the Allalingrat, shows green amphibole and white saussurite. The former is no longer in distinct pseudomorphs after diallage, but has a fibrous and flaky habit, and is embedded in the saussurite. The latter is more distinctly granular or saccharoid to the eye than in the non-banded gabbros. It consists mainly of clear albite, with zoisite and paragonite. The green portion of the rock consists of actinolite prisms, rich in rutile, and some clinochlore. The last-named mineral is more abundant in the more strongly foliated rocks, where it apparently replaces the actinolite.

The structural characteristic of most of the well foliated and schistose rocks is the occurrence of little lenticular white saussuritic patches (consisting of zoisite, felspar and epidote) in a green amphibole-clinochlore-aggregate. Examples are described from the Egginerhorn and Mittaghorn: others from the Strahlhorn and Hinterallalinhorn are rich in garnet and poorer in saussurite. In specimens from the Gletscheralp

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clinochlore more or less completely excludes actinolite, and becomes the dominant constituent, while apatite is abundant in irregular grains.

A number of occurrences of serpentine are noted in the district. The chief point of interest here is the occurrence of two monoclinic minerals of the humite family, one brown, the other pale yellow to colourless. They occur either as granular lumps or groups of little grains in the serpentine, or as rounded prisms, 1 cm. long, in masses of crystalline limestone enclosed in the serpentine. The crystals show a polysynthetic twinning parallel to the base. The plane of the optic axes is perpendicular to the clinopinacoid: a clinopinacoidal section gives an extinction-angle of about 30°, and shows the acute, negative bisectrix. The brown variety gives pleochroism: α = pale yellowish, β = rusty brown (reddish yellow), γ = pale yellowish. Its specific gravity is 3·17 to 3·18, that of the pale variety 3·165. Chemical analyses by Jannasch and Locke gave I. for the white mineral and II. for the brown (both corrected for impurities and recalculated to 100).

	I.	II.
SiO_2	33·03	37·80
FeO	3·78	5·70
BeO	1·75	1·03
CaO	7·00	0·10
MnO	0·80	0·76
MgO	50·16	50·88
Na_2O	0·55	0·36
H_2O	2·93	3·34

The formula deduced is $Mg_5[Mg.OH]_2(SiO_4)_3$, the usual fluorine being wholly replaced by hydroxyl. The precise nature of the parent-rock of the serpentine masses is somewhat uncertain, but it was clearly in genetic relationship with the gabbro group.

These gabbros and associated basic rocks constitute a complex intercalated in the gneisses, mica-schists, and limestones of the district, and sharing with these the effects of orogenetic pressure. These effects are seen in the passage of normal gabbro through granular and then foliated saussurite-gabbros to coarsely and at last finely foliated green-schists. The setting up of schistosity is always accompanied by mineralogical transformations, ascribed to pressure, but the converse is not true; witness the massive saussurite-gabbro. The massive and granular, less altered, rocks form the core of the complex, the most metamorphosed types the margins. A. H.

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Mica-syenite in Saxony.—J. M. C. Henderson gives an account of certain dyke-like intrusions of mica-syenite at Rothschönberg, near Deutschenbora, in Saxony (*Zeits. deuts. geol. Ges.*, Vol. XLVII, 534, 1895). The rocks consist essentially of felspars (orthoclase and plagioclase in about equal quantities), mica (in one case muscovite as well as biotite), magnetite, and apatite with accessory quartz (in part secondary) and calcite. A chemical analysis gave the result in column I; a specimen from another outcrop gave II.

	I.	II.	III.	IV.	V.
SiO_2	61·40	57·63	60·15	61·35	61·30
Al_2O_3	16·66	16·47	20·20	18·28	17·10
Fe_2O_3	7·46	5·37	12·28	11·49	10·97
MgO	3·65	4·44	0 96	1·98	3·01
CaO	2·08	5·25	0·70	0·84	0·87
Na_2O	4·75	5·15	1·00	1·78	1·79
K_2O	2 93	3·12	3·43	3·55	4·07
H_2O	0·76	0·45	2·89	2·35	1·48
CO_2	1·54	2·14	—	—	—
S	0·20	0·95	—	—	—
	101·43	100·97	101·61	102·32[1]	100·59

Perhaps the most interesting part of the paper is that relating to the metamorphism of the adjacent phyllites. Three analyses were made; III. of the unaltered rock 2 meters from the junction, IV. altered at 1 meter, and V. in contact with the syenite. The quartz of the phyllite was found to decrease on approaching the junction, the three specimens analysed giving respectively 43·38, 38·94, and 34·06 per cent. The combined silica must therefore increase. There is a notable increase in the amount of biotite, which must be formed mainly at the expense of chloritic material. Now comparison of the three analyses shows certain differences, which seem to indicate, in the neighbourhood of the syenite, an accession of magnesia, potash, and soda, and a loss of water. It is not necessary, to conclude, however, that material has been actually introduced into the phyllite from the igneous rock. The removal of alkalies and magnesia from rocks by weathering action is a well-known fact, and the author remarks that this would take effect to a less extent in the metamorphosed rock (with biotite in place of chlorite) than in the

[1] Including 0·70 of MnO.

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normal phyllite; so that if immediately after metamorphism these rocks had the same chemical (though different mineralogical) composition, ordinary weathering would produce such a difference as is shown by the analyses. A. H.

Peridotites and amphibolites in Piedmont. In a memoir on the geology of the neighbourhood of Finero, C. Porro gives an account of an interesting group of basic and ultrabasic rocks in the district west of L. Maggiore (*Zeits. deuts. geol. Ges.*, Vol. XLVII, 377, 1895). The chief outcrops form a broad belt running north-easterly from Ivrea to Locarno, intercalated among the gneisses of the Western Alps. The rocks themselves divide into (1) peridotites and (2) felspathic amphibolites and pyroxenites.

Of the peridotites some are quite fresh, and consist of olivine to the extent of about 80 per cent. The other minerals are enstatite, rarely diallage, and chrome-diopside, hornblende, biotite, brown chrome-spinel and pleonaste, and in one case corundum.

	I.	II.	III.
SiO_2	41·74	43·12	49·03
TiO_2	0·19	0·20	—
Al_2O_3	1·14	0·63	13·14
Fe_2O_3	5·70	5·95	6·91
FeO	3·09	4·09	8·60
MgO	43·60	41·69	3·67
CaO	0·14	0·78	12·10
Na_2O	0·59	0·88	3·40
K_2O	0·41	0·19	0·24
Ignition	4·77	not det.	1·70
	101·37		98·79

Hornblende is most abundant towards the edge of the peridotite. Columns I. and II. show the results of analyses by Philippi of a slightly serpentinised peridotite and a fresh example, from different localities. By alteration the peridotites have given rise to serpentine-rocks, some containing chlorite, talc and tremolite; and a talc-schist at Finero, consisting of talc and tremolite, has probably also originated from a peridotite.

Among the hornblendic and pryoxenic rocks Porro distinguishes (i.) pyroxene-bearing felspar-amphibolite, (ii.) schistose and partly fibrous

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felspar-amphibolite, (iii.) hornblende-bearing felspar-pyroxenite, (iv.) coarsely banded felspar-amphibolite. The first, which occurs in considerable amount, is seen under the microscope to consist of brown hornblende, clear lime-soda-felspar, and subordinate green pyroxene, with red garnet, sphene, rutile, biotite, etc., as accessories. Column III. shows a chemical analysis (mean of two) by Seyfried. This rock passes in places into the schistose variety, poor in felspar, which occurs as a rule as lenticular intercalations in the gneisses which bound the main belt of basic rocks. In this rock the hornblende is green and fibrous. Corundum is a noticeable accessory. Not only towards the gneiss, but also towards the peridotite does the pyroxenic felspar-amphibolite show a marginal modification. Here the structure changes, and pyroxene takes the leading part instead of hornblende. A parallel-structure becomes more marked; grains of garnet, pyroxene and hornblende tend to give a porphyritic appearance to the rock; and the felspar is partly segregated into narrow parallel white bands and lenticular streaks. This is the hornblendic felspar-pyroxenite. Nearer to the peridotite the dark-green bands become more predominant, and the texture is finer. The pyroxene is seldom uralitised, but part of it is converted into chlorite, tremolite and epidote, while part remains fresh, suggesting that two different kinds of pyroxene have been present. In the body of the peridotite itself occur small portions of a rock generally similar to this pyroxenite. The last of the four types, the coarsely banded felspar-amphibolite, occurs as lenticular masses in the peridotite, and, unlike the pyroxenite, it is not very sharply marked off from the ultrabasic rock. The texture is coarse, and the dark hornblendic and light felspathic bands are sometimes more than 30 cm. broad. Pyroxene occurs only sparingly; garnet is often abundant in the dark bands.

All these basic rocks, including the peridotite, are to be regarded as true igneous rocks intruded among the gneisses, and especially between the "Sesia Gneiss" and the "Strona Gneiss," while these latter were still undisturbed; and they have been affected in common with the gneisses by the orogenetic forces. After comparison of the several rocks and special study of their contact-phenomena, the author concludes that the peridotite and the felspar-amphibolite with its varieties come from one original rock-magma, which became differentiated prior to, or at the beginning of, the intrusion into a felspar-amphibolite-magma and a peridotite-magma. These two forced their way in among the gneisses in the order named, though portions of the former magma entangled in the latter separated out later as lenticular masses of coarse felspar-amphibolite in

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the peridotite. The chief "contact" effect between the two rocks is the conversion of hornblende to augite in the felspar-amphibolite, which is ascribed to the chemical agency of the peridotite-magma. A. H.

Missourite, a new leucite rock. W. H. Weed and L. V. Pirsson (*Am. J. Sci.* II. 1896, 315-23) describe a new rock type from the Highwood Mountains of Montana. The rock forms an intrusive stock (2½ miles long, and in places half as wide) in cretaceous shales. It is a dark gray, coarse-grained, evenly granular rock, consisting of leucite, augite, olivine and biotite, with apatite and iron ore. The structure is purely granitoid, and all the minerals are wholly allotriomorphic. As regards classification, the rock is the plutonic representative of the leucite-basalts. G. T. P.

The Monchiquites or Analcite Group of Igneous Rocks. L. V. Pirsson (*Journ. Geol.* IV. 1896, No. 6) brings forward evidence in support of the view that the so-called glassy base in rocks belonging to the Monchiquite group of Rosenbusch consists really of analcite. In the analysis of specimens free from biotite and ægirite, and in which presumably the alkalies, alumina and water were in the base, the molecular ratios of these constituents were as 1 : 1 : 2, as in analcite. In the original analysis of Hunter of the base of the Brazilian Monchiquites, the molecular ratios of silica, alumina, alkalies and water are as 4 : 1 : 1 : 2. The author concludes, therefore, that as the base has the exact chemical composition, the exact specific gravity, the property of gelatinising with acids, and the optical properties of analcite, it must be that mineral, and not a pitchstone glass, as formerly supposed.

The author considers that the analcite in the monchiquites and in many other rocks is a primary constituent, and that as we have a leucite group of rocks, so we must now recognise an analcite group. The analcite-basalts corresponding to leucite-basalts are the monchiquites of Rosenbusch, while the olivine-free analcites corresponding to leucitites are the fourchites of J. F. Williams. G. T. P.

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Fig. 2.

Fig. 3.

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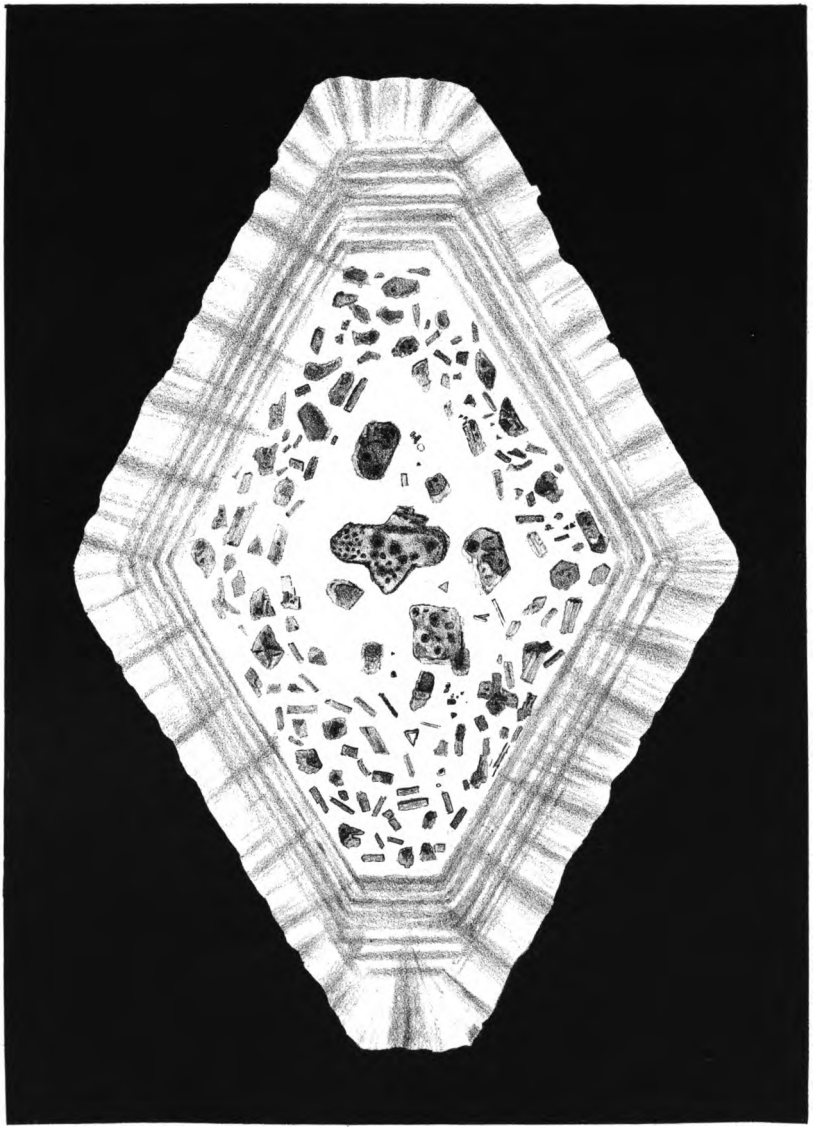

J.P.O'Reilly del.

Mintern Bros. lith.

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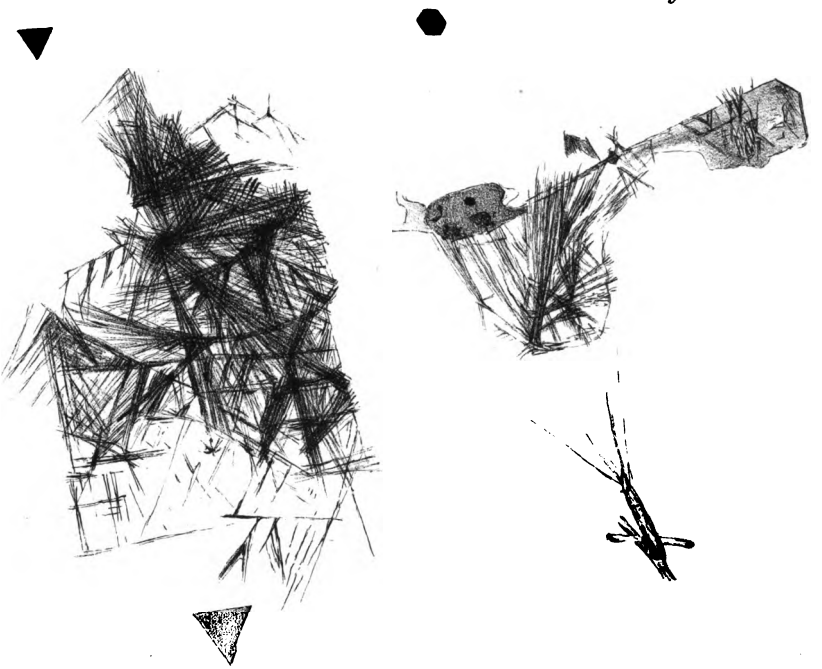

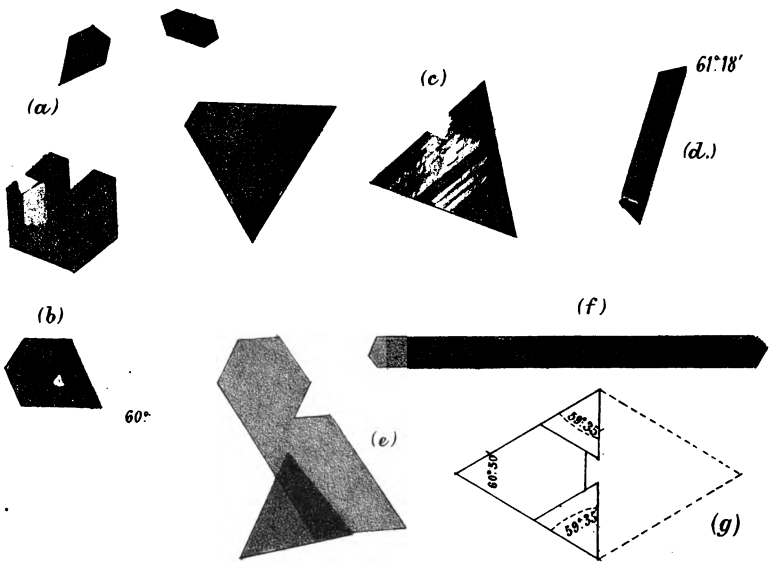

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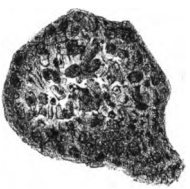
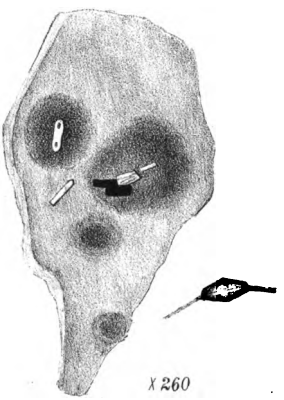
x 27

x 70

x 40 (a)

x 20 (b)





x 260

(c)

(d)

J.P.O'Reilly del.

Mintern Bros. lith.

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THE MINERALOGICAL MAGAZINE

AND

JOURNAL

OF THE

MINERALOGICAL SOCIETY.

No. 53. DECEMBER 1897. Vol. XI.

On some British Pseudomorphs.

By H. A. Miers, M.A., F.R.S.,

Professor of Mineralogy in the University of Oxford.

[Read April 14th, 1896.]

I. Some British Pseudomorphs, hitherto undescribed.

1. APATITE after Cronstedtite; from Wheal Maudlin, Llanlivery, Cornwall.

A specimen in the British Museum, consisting mainly of brown chalybite and decomposed iron pyrites—the latter mostly converted into earthy oxides—bears upon its surface and in its cavities a number of thin prisms encrusted with a botryoidal yellowish substance which covers a great part of the decomposed specimen. On close inspection the needles are seen to be Cronstedtite, mostly but not entirely converted into black limonite, and the encrusting substance consists mainly of phosphate (with a little carbonate) of lime. The latter is sometimes crystalline on its surface.

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2. Calcite after Quartz; from Cork, Ireland.

A specimen in the British Museum collection consists of compact grey limestone, containing small doubly terminated prisms of quartz. These have been converted, some wholly, some partly, into calcite. The change has taken place in zones which follow the contour of the crystals, and sometimes, when the conversion has been almost complete, zones of quartz remain alternating with bands of calcite.

Some of the quartz crystals are entirely unaltered. The change is to a massive calcite rather more white than the surrounding limestone; it appears to have begun sometimes in the interior of the crystal, and to have extended thence towards the surface.

This may be due to the change having spread from zones of enclosed calcite, but the specimen is a true pseudomorph, and not merely an enclosure of calcite in quartz.

The replacement of quartz by calcite has been recorded from Bohemia.

3. Calcite after Celestine (?); from Durham.

Several specimens acquired by the British Museum in 1857 are crystals of a brown colour, embedded in calcareous clay, which were found in the Jarrow Docks at Durham.

These have the form of elongated, doubly terminated, acute rhombic pyramids, with curved faces. They resemble in form the well-known "barley-corn" pseudomorphs from Sangerhausen and from Schleswig, and are almost identical in aspect with a similar pseudomorph from Archangel in Russia.

They also resemble the large pseudomorphs from Hunter River, in New South Wales, described by Dana in the *Geology of the United States Exploring Expedition round the World* (see Liversidge, *Minerals of New South Wales*, p. 161). In my opinion all these crystals are pseudomorphs after celestine, which exhibits a remarkable tendency to crystallise in acute pyramids with curved faces (see Williams, *Am. J. Sci.* XXXIX. 188, 1890, and *cf. Min. Mag.* X. 39).

The specimens from Durham sometimes attain a length of 1½ inch; some are compact, and of a uniform brown colour, and have an unevenly drusy surface, as though etched; others have been completely converted into granular and porous concretions of a yellow calcite.

These pseudomorphs have been known by the name of Jarrowite, but have not hitherto been described, so far as I have been able to ascertain.

4. Cerussite after Lanarkite; from Leadhills, Lanarkshire.

A specimen in the British Museum consists of crystallised cerussite

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encrusting altered prisms which have the aspect of lanarkite and consist in the interior of mixed carbonate and sulphate of lead.

This replacement has not been hitherto recorded.

5. Chalcopyrite after Calcite; from Cornwall.

A compact mass of chalcopyrite with rough surface, apparently the apex of a large scalenohedron. So far as can be determined with the hand goniometer, it seems to be that of the common scalenohedron $\{20\bar{1}\}$ of calcite. There is also a little quartz on the specimen.

Such a pseudomorph has not hitherto been recorded.

6. Chalcopyrite after Bismuthite; from Tavistock, Devonshire.

Uneven channelled prisms entirely converted on the surface and to a considerable depth into chalcopyrite. In some instances the core of bismuthite has been partly removed. The accompanying minerals are chalcopyrite, milky quartz and pyrites, upon a matrix of chloritic slate.

7. Chalcopyrite after Bismuthite; from Fowey Consols mine, St. Blazey, Cornwall.

In this specimen the prisms of bismuthite have been entirely converted into a mixture of chalcopyrite and a black material which contains bismuth and sulphur. The pseudomorphs lie for the most part in a matrix, consisting of chloritic slate, quartz, chalcopyrite and erubescite.

The replacement of bismuthite by chalcopyrite has not hitherto been recorded.

Chalcopyrite after Bournonite; from Herodsfoot mine, Liskeard, Cornwall. See No. 13.

8. Chalybite after Bismuthite; from Fowey Consols mine, St. Blazey, Cornwall.

A specimen in the British Museum shows pseudomorphs of chalcopyrite after bismuthite, which have been converted on the surface into a pale blue substance. These are dispersed on chalcopyrite, and they are encrusted with crystallised chalybite. In some instances the altered prisms appear to have been completely replaced by chalybite.

The chalybite lies almost exclusively upon the pseudomorphs, and scarcely at all upon the chalcopyrite.

This replacement has not been hitherto recorded.

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9. Chlorite after Mispickel; from Carn Brea, Cornwall.

These are hollow drusy pseudomorphs of chlorite in a form which at first sight appears to be that of the obtuse rhombohedron {110} of calcite. Closer inspection shows that they have the form of mispickel, a combination of the prism {110} with an obtuse macrodome; the prism angle was roughly determined as about 65°. The pseudomorphs are disposed on a matrix of compact chlorite, and are accompanied by a later deposit of tarnished crystals of erubescite and a little chalybite.

The pseudomorph has not hitherto been recorded.

10. Copper after Cuprite; from Cornwall.

A pseudomorphous replacement of cuprite by copper is mentioned by Sillem (*Neues Jahrbuch für Mineralogie*, 1851, p. 385), who gives two localities, namely Penzance and Cuba, but without description.

It is more than probable that his note is based upon two specimens in the British Museum; one of these formerly belonged to the collection of Mr. R. P. Greg, in whose catalogue (dating from the time when the collection belonged to Mr. R. Allan, the catalogue itself having been made by Haidinger) it is entered as from Cuba; the specimen was, however, identified as Cornish, and from Tresavean mine, St. Day, by the late Mr. T. Davies, whose knowledge of Cornish mineral localities was unerring. The other specimen has all the appearance of being Cornish, and was identified by Mr. Davies as from the Relistian mine, Camborne. A third specimen in the British Museum is from Liskeard.

It is remarkable that this pseudomorph is not of more common occurrence. It does not seem to have been described. The characteristics of the specimens are as follows:—

(*a*). Tresavean mine, St. Day. Very perfect cubes and combinations of cube with dodecahedron, consisting of firmly compacted pure copper, but obvious pseudomorphs. The copper, though crystallised, has a drusy and slightly cavernous surface; it is brilliant, and for the most part brightly tarnished.

There is nothing else on the specimen except angular fragments of vein-quartz, a little copper independently crystallised in rounded crystals, and a trace of some black mineral.

There is no regular orientation of the copper in the pseudomorph.

(*b*). Relistian mine, Camborne. Crystals somewhat similar to those in the preceding specimen, accompanied by long blade-shaped crystals of copper. On this specimen the metal is not tarnished, and the matrix

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consists of schorl cementing a little fragmentary quartz. The schorl sometimes fills cavities in the mass of copper.

Both these pseudomorphs are complete, and no cuprite remains.

(*c*). Liskeard. A large octahedron of cuprite partly converted into copper.

11. Erubescite after Chalcopyrite; from Cornwall.

These are uneven crystals of very irregular form, but somewhat resembling those from Wheal Towan. They consist partly of chalcopyrite, but have been converted near the surface, and in some instances to a considerable depth, into erubescite.

They are dispersed among quartz crystals, the matrix being clay-slate.

A recently acquired specimen, showing a similar replacement, is from St. Ives Consols mine. Here the resulting substance seems to be a mixture of erubescite and earthy red oxide of copper, and the pseudomorphs are accompanied by crystals of copper glance dispersed upon them, together with a little chrysocolla.

12. Fluor after Calcite; from Derbyshire.

Large scalenohedra of calcite replaced by a mass of cubes of yellowish fluor enclosing chalcopyrite.

These appear to have been epimorphs in which, after removal of the calcite, the cavity has been largely refilled by fluor. Upon one side of the specimen the calcite still remains.

Pseudomorphs of fluor after calcite have previously been described from Breisgau.

13. Galena and Chalcopyrite after Bournonite, from Herodsfoot mine, Liskeard, Cornwall

There are two fine specimens in the British Museum. In these the well-known wheel-shaped groups of bournonite associated with quartz (after barytes) have been corroded and partly replaced by galena, chalcopyrite and tetrahedrite.

The original form of the bournonite tables is well preserved by a thick crust, consisting of large crystals of galena disposed in a regular manner upon the prism faces of the bournonite. The basal surfaces of the bournonite have been for the most part removed, so that the ring of galena surrounds a comparatively thin corroded disc of bournonite, while chalcopyrite and tetrahedrite are dispersed about the cavity so formed and upon the edges of the galena crystals. The tetrahedrite is always

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covered with the thin crust of chalcopyrite so familiar in the Herodsfoot specimens.

The galena crystals (which are combinations of cube and dodecahedron) are arranged in such a way that an edge of the octahedron is always parallel to the prism edge of the bournonite; and the general disposition of the crystals suggests that in all probability a cube and dodecahedron face of the galena were parallel to the brachy-pinacoid and the macro-pinacoid respectively of the bournonite.

There is no direct evidence that the galena was not deposited as a crust upon the bournonite prism faces before the decomposition of that mineral; but there is no reason to doubt that the galena, the tetrahedrite and the chalcopyrite have all resulted from the decomposition of the bournonite.

On the other hand, it is remarkable that, whereas bournonite corresponds to a compound consisting of one molecule of tetrahedrite, eight of galena and three of stibnite, there is no trace on these specimens of any antimony compounds such as might be expected to remain after the conversion of bournonite into galena and tetrahedrite.

Sometimes a direct conversion (upon the surface) of bournonite into chalcopyrite has taken place.

A pseudomorph of this nature has not hitherto been described, except from Kapnik.

In Greg and Lettsom's *Mineralogy*, p. 346, it is alluded to as "bournonite filling hollow crystals of galena," a totally false description.

14. Galena after Anglesite; from Derbyshire.

This pseudomorph is only mentioned in Greg and Lettsom's *Mineralogy* (p. 450), without description or locality.

The specimen in the British Museum is from the Allan-Greg collection (see above, No. 10), where it is labelled as from Derbyshire, and has all the appearance of the large crystals formerly found in the neighbourhood of Matlock.

It is a true pseudomorph; the large prism is entirely converted on the surface into a smooth crystalline coating of galena; the alteration has proceeded to a considerable depth, through which the material is a mixture of anglesite and galena; and the interior consists of unaltered anglesite.

There is also a specimen labelled Matlock in the Ludlam collection, now in the Museum of Practical Geology, Jermyn Street.

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15. Hæmatite after Fluor; from Lancashire and Cumberland, and St. Just, Cornwall.

The specimens from Furness, Lancashire, are cubes which appear to have been converted into quartz and then covered and partially or entirely replaced by earthy and fibrous hæmatite. They should, therefore, be described as hæmatite after quartz after fluor. Since the cubes do not show the characteristic interpenetrating twinning of fluor, they are often supposed to be pseudomorphs after pyrites, and are so described. In reality the direct replacement of pyrites by hæmatite or by quartz appears to be as rare as that of fluor by silica is common; so that many so-called pseudomorphs of hæmatite after pyrites are doubtless in reality after fluor, which has been altered to silica. This may be true of the specimens from Spitzleite, which closely resemble those from Lancashire and Cumberland. Pyrites is generally transformed into hydrate of iron, and not into hæmatite (see, however, No. 16 below).

On the Lancashire specimens, which are from Dalton-in-Furness and from the Stank mine, the tendency of fibrous hæmatite to form botryoidal and rounded masses has caused the edges and corners of the cubes to become completely rounded on the surface, although the pseudomorph in the interior is generally quite a sharp cube. A central cavity is often partially filled with crystallised calcite.

A specimen from Hodbarrow mine, Millom, Cumberland, precisely resembles those from Lancashire; and similar cubes encrusted with black limonite occur on the specimen from Wheal Owles described below, under No. 22.

These pseudomorphs have not been hitherto described.

16. Hæmatite after Pyrites; from Cumberland.

This specimen is an undoubted example of the conversion of pyrites into hæmatite. The crystals are characteristic combinations of a striated cube with the pentagonal dodecahedron $\pi\{210\}$. They have been entirely converted into a material which, though in the interior of the crystals rather dark coloured for hæmatite, is in reality the anhydrous oxide, since it only loses 0·3 per cent. of its weight on ignition.

Similar pseudomorphs from Torquay, Devonshire, have been described by Solly and Hutchinson in this Magazine (Vol. VIII., 1889, p. 183).

A replacement of pyrites by hæmatite from Donegal has also been recorded (without description) in Hall's *Mineralogist's Directory*.

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17. Hæmatite after Calcite; from Furness, Lancashire.

These specimens, from the Stank mine, are scalenohedra completely replaced by earthy and fibrous red hæmatite. The edges and corners of the pseudomorphs are rounded in the same way as in those of hæmatite after fluor.

18. Hæmatite and Limonite after Calcite; from Bristol.

A flat surface of sharply crystallised scalenohedra twinned upon the basal plane, resembling in aspect the well-known pseudomorphs from Spitzleite.

The only British localities previously recorded for this replacement are Cornwall (in Greg and Lettsom, p. 249) and Parkside mine, Cumberland (in Hall's *Mineralogist's Directory*).

The replacing material is partly limonite, and in one specimen consists mainly of limonite. Here the fibrous structure shows that the original pseudomorph was hæmatite after calcite, and that the hæmatite has been converted into limonite.

19. Hæmatite and Redruthite after Pyrites; from St. Just, Cornwall.

A group of large cubes entirely converted into a material which consists mainly of crystalline hæmatite, but contains also a proportion of copper which appears to be present, partly at least, as redruthite. The specimen is from the Levant mine. Another specimen from Cornwall is a large cube coated with earthy melaconite. The interior is a compact mineral containing sulphur, iron and copper, possibly also a mixture of hæmatite and redruthite.

Limonite after Calcite; from Bristol. See No. 18.

20. Limonite after Cronstedtite; from Wheal Jane, Truro, Cornwall.

In some of these specimens the typical crystals of cronstedtite have been completely transformed into limonite.

The pyrites upon which they were situated has also been altered to limonite, but only to a very slight depth, below which the material is quite unaltered.

This replacement has not previously been recorded.

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21. Limonite after Fluor; from Redruth, Cornwall.

Cubes of black limonite, with rounded edges and corners, from Cook's Kitchen mine, seem to be in all probability pseudomorphs after fluor. Where these have been broken the original substance is found to have been entirely removed, and the fibrous structure of the enveloping substance shows that it was formerly hæmatite. The cubes are therefore to be described as hæmatite epimorphs after fluor, which have been converted into limonite. The limonite also encrusts accompanying crystals of quartz.

Sharp cubes consisting of a mixture of quartz and limonite from Wheal Owles, St. Just, may also be pseudomorphs after fluor. The centre of the cubes consists mainly of granular quartz.

22. Limonite after Hæmatite; from Wheal Owles, St. Just, Cornwall.

The specimen referred to above (under 15) consists mainly of sharp cubes, consisting of quartz (pseudomorphs after fluor) coated or superficially replaced by limonite. These are accompanied by crystals having the form of hæmatite, which have been completely transformed into limonite.

The replacement has only been previously recorded by Collins (*Min. Cornwall and Devon*, p. 80), on doubtful authority, as from Restormel.

23. Magnetite after Picrolite; from Scalpa, Isle of Harris, in the Hebrides.

In a specimen of picrolite from this locality the fibres have been largely converted into magnetite, in which the structure of the original mineral is well preserved.

The specimen somewhat resembles one from Piedmont, in which a similar replacement has taken place. It has not been previously recorded from a British locality.

24. Malachite after Cerussite; from Redruth, Cornwall.

A specimen in the British Museum, formerly belonging to the Allan-Greg Collection, consists of a mass of small green crystals upon a quartzose matrix. The crystals consist entirely of malachite, but they have the form of rhombic tables with bevelled edges sometimes irregularly grouped together, but sometimes twinned like cerussite. Some of the crystals also have the aspect of acute pyramids. Mr. G. F. H. Smith has kindly measured some of these crystals, and finds their angles to be approximately those of cerussite. The locality is mentioned by Hall.

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Marcasite after Pyrrhotite; from Cornwall. See No. 28.

25. Plumbo-resinite after Barytes and Pyromorphite; from Roughten Gill, Cumberland.

Familiar in most old collections are the specimens from Roughten Gill, in which pyromorphite in crystals or botryoidal groups lies upon a sky blue mineral encrusting the matrix. The blue mineral is probably generally regarded as silicate or carbonate of zinc.

On one specimen in the British Museum, which formerly belonged to the Allan-Greg collection, the blue mineral encrusts thin tabular crystals of barytes, and upon the epimorph are dispersed small yellow crystals of pyromorphite. Greg and Lettsom mention carbonate of zinc after barytes without the locality, and the label which accompanies the specimen leaves no doubt that this is the specimen to which their allusion refers.

The blue mineral was found by Mr. Prior to be neither carbonate nor silicate of zinc, but the phosphate of lead and aluminium known as plumbo-resinite.

The occurrence of plumbo-resinite at Roughten Gill is first mentioned in the 3rd edition of Dana's *System* in 1850. It is not mentioned in the 2nd edition of 1844.

Plumbo-resinite pseudomorphous after barytes has not hitherto been recorded.

The elaborate description in Blum's *Pseudomorphosen*, Vol. I. p. 273, of pseudomorphs of silicate of zinc after pyromorphite from Caldbeck Fell probably relates to this substance.

26. Pyrites after Barytes; from Liskeard, Cornwall.

This pseudomorph is mentioned by Collins, from Herodsfoot mine, on the authority of Pearce, but has not been described.

The British Museum collection contains several specimens of well-defined hollow epimorphs of pyrites; in no case is any trace of the original mineral remaining, and the only evidence of its nature is the characteristic form of the rhombic tables, a combination of {001} and {110} so familiar in barytes. On one specimen from Wheal Trelawney, which consists practically of a continuous crystal of pyrites completely covered with sharp impressions of barytes crystals, the prism angle bounding the tabular hollows could be measured from the sides of the casts by the reflecting goniometer, and was found to be 78°30′.

On the other specimens the epimorphs consist of small cubes of

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pyrites massed together irregularly. A somewhat similar specimen from Tavistock seems to consist of marcasite.

There is also a specimen from Liskeard in the Jermyn Street Museum.

27. Pyrites after Barytes; from Cumberland.

This consists of a large hollow epimorph of the same form as the preceding, and composed of small polysynthetic cubes of pyrites. The hollow has been entirely filled with drusy prisms of milky calcite, a combination of $\{2\bar{1}\bar{1}\}$ and $\{110\}$. The calcite is also dispersed over the surface of the epimorph.

This occurrence has not been previously described.

28. Pyrites and Marcasite after Pyrrhotite; from Cornwall.

These pseudomorphs are thin hexagonal plates, consisting entirely of cubes of pyrites which have completely replaced the original mineral. They are implanted upon a matrix consisting of blende and massive pyrites. The associated minerals are a little quartz and pearlspar. The cubes of pyrites which constitute each hexagonal plate are for the most part arranged in regular position, and parallel to each other.

In one specimen from Wheal Seaton, Camborne, the pseudomorphs are beautiful hollow plates with a drusy surface, and with large pyramid faces.

Another Cornish specimen shows the plates in the more characteristic form of low hexagonal pyramids, but the material here appears to be marcasite. These are associated with blende. These pseudomorphs have not been described before; they are well known from Freiberg.

A specimen in the Jermyn Street Museum is from Redruth.

29. Pyrites after Quartz and Fluor; from Cornwall.

An epimorph in which pyrites, in thickly accumulated somewhat rounded and drusy crystals, completely encrusts milky quartz. These are accompanied by large hollow octahedral epimorphs, possibly after fluor, from which the original mineral has been entirely removed, leaving only small milky crystals of quartz upon which the original octahedra were deposited.

The specimen was originally in the Allan-Greg collection, and the locality is given on the authority of the label which accompanies it.

Pyrites after quartz has not hitherto been recorded among British pseudomorphs, and pyrites after fluor only from Alston.

30. Quartz after Barytes; from Liskeard and Devonshire.

Pseudomorphs of chalcedony after barytes are mentioned by Greg and

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Lettsom as having been recently found at Herodsfoot mine and Wheal Mary, in Cornwall; and quartz after barytes from Durham is recorded by Hall.

Excellent pseudomorphs of quartz after barytes are common from Herodsfoot mine at Liskeard, accompanying bournonite. These appear to have been originally epimorphs of quartz after very thin tabular plates of barytes, in which the barytes has been subsequently removed and replaced by quartz. There is no trace of barytes left upon these specimens.

Epimorphs of quartz after barytes also occur at Wheal Mary Ann, Liskeard, and probably also in Devonshire.

It is remarkable that these epimorphs have not been previously described.

31. Quartz after Barytes (?); from Blackwell Down, Somersetshire.

Two specimens in the British Museum from this locality consist of a fibrous mineral which has been entirely replaced by quartz. The fibres are curved and show a tendency to arrange themselves into radiating groups, and are pinkish in colour. Mr. Prior has kindly examined one of these specimens at my request, and finds it to contain barium.

The mineral overlies quartz on a matrix of quartzose ironstone. Blackwell is one mile south-east of Nailsea, and seven miles south-west of Bristol.

32. Quartz after Bournonite; from Liskeard, Cornwall.

Among the metallic minerals upon which quartz is deposited bournonite is conspicuous. On the specimens from Liskeard the wheel-shaped groups of bournonite are frequently plated with a layer of quartz. In one specimen from the Herodsfoot mine the bournonite has been partly removed or converted into a mixture of galena and chalcopyrite, as described above under 13, and the result is a hollow epimorph of quartz after bournonite.

This has not been previously recorded.

33. Quartz after Silver; from Cornwall.

A specimen from the Allan-Greg collection, labelled Cornwall, consists of quartz crystals, among which are dispersed groups of crystallised chalcopyrite, accompanied by overlying crystals of marcasite. A still later deposit of quartz is a mass of wiry form, which, on close examination, is seen to consist of minute crystals completely enveloping fine threads of black mineral, to which the wiry form is due. The mineral

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appears to be argentite, doubtless itself a pseudomorph after native silver.

The large quartz crystals which constitute the main part of the specimen are themselves overlaid with a deposit of secondary quartz, which lies smoothly on the pyramid faces, but gives a drusy surface to the prism faces; and upon them are scattered a few hollow pseudomorphs of quartz after curved rhombohedra of calcite (or dolomite).

The history of this interesting specimen is very clearly told by the succession of minerals. The original minerals were quartz succeeded by chalcopyrite, marcasite, chalybite and native silver in order. The silver has been converted into argentite. Then has come a secondary deposit of quartz, which has completely coated the chalybite and the argentite, and has increased the earlier quartz crystals, but has almost absolutely avoided the other metallic minerals.

This specimen illustrates the value of a study of epimorphs as indicating the tendency exhibited by a given mineral to crystallise only upon certain minerals, and not upon others. In this connection the reluctance of quartz to crystallise upon the metallic minerals is strikingly conspicuous. A survey of any mineral collection brings this fact to light at once; and among the very complete list of pseudomorphs enumerated in the first volume of Roth's *Allgemeine und chemische Geologie*, the only pseudomorph of quartz after a metallic mineral mentioned is that after galena. Pseudomorphs of quartz after pyrites recorded by Carne[1] are not supported by any other authority (see below, p. 279).

Epimorphs of quartz after silver or argentite have not been previously recorded.

A specimen in the British Museum collection from Freiberg presents a precisely similar encrustation by quartz of wiry silver altered into argentite.

Redruthite after Pyrites; from St. Just, Cornwall. See No 19.

34. Redruthite after Erubescite; from Redruth, Cornwall.

A specimen in the Ludlam collection, now in the Museum of Practical Geology, Jermyn Street, appears to be a single cube of erubescite in a quartz geode, converted into redruthite.

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[1] *Trans. Roy. Geol. Soc. Cornwall*, 1816, VI. 28.

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II. British Pseudomorphs for which the evidence is insufficient or incorrect.

(*Many of these may be genuine, and it is hoped that their present provisional separation may lead to the re-identification of such*).

Analcime after Calcite is recorded by Greg and Lettsom, but without description.

Aragonite after Witherite is recorded by Greg and Lettsom, but without description or locality.

Barytes after Analcime is recorded by Greg and Lettsom, but without description or locality.

Bournonite after Galena, from Herodsfoot mine; recorded by Greg and Lettsom; see above, No. 13.

Calamine after Barytes is Plumbo-resinite after Barytes (see above, No. 25).

Calamine after Galena is recorded by Greg and Lettsom, but without description or locality.

Chalcopyrite after Blende, from Cornwall, is recorded by Greg and Lettsom, and also by Collins and by Hall, but the evidence seems doubtful.

Chalcopyrite after Chalybite is mentioned by Greg and Lettsom without description or locality, and by Hall as from St. Just.

Chalcopyrite after Dolomite is recorded by Carne as from Huel Tolgus, and is mentioned by Collins, but the evidence in favour of this being a psuedomorph is insufficient.

Chalcopyrite after Pyrites (in cubes) is mentioned by Carne, but the statement is not repeated by Collins, and has no further evidence to support it.

Chalybite after Galena is recorded by Greg and Lettsom, but without description or locality.

Chalybite after Selenite, from Devonshire, recorded by Greg and Lettsom, is probably after Barytes.

Chlorite after Albite is recorded by Collins, but without description.

Chlorite after Fluor is recorded by Greg and Lettsom, but without description or locality.

Chlorite after Garnet is recorded by Greg and Lettsom, but without description or locality.

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Chrysocolla after Cerussite and Galena, from Leadhills; recorded by Greg and Lettsom.

Chrysocolla after Cupro-uranite, from Cornwall, is recorded by Greg and Lettsom, but requires confirmation.

Cuprite after Chalcopyrite is recorded by Greg and Lettsom, but without description or locality.

Fluor after Felspar is recorded by Collins, on the authority of Pearce.

Galena after Barytes is recorded by Greg and Lettsom, without description or locality.

Green-earth after Barytes is recorded by Greg and Lettsom, but without description or locality.

Hæmatite after Barytes, from Ulverstone, is recorded by Greg and Lettsom, but requires confirmation.

Hæmatite after Galena is recorded by Greg and Lettsom, but without description or locality.

Hæmatite after Marcasite is recorded by Greg and Lettsom, but without description or locality.

Hemimorphite after Pyromorphite is Plumbo-resinite after Pyromorphite (see above, No. 25).

Kaolin after Fluor is recorded by Greg and Lettsom, but without description or locality.

Limonite after Dolomite is recorded by Collins on the authority of Pearce, but requires confirmation.

Limonite (?) after Felspar, from Carnmouth, is recorded by Collins, but requires confirmation.

Limonite after Psilomelane, from Hoy in the Orkneys, is recorded by Greg and Lettsom; but see *Min. Mag.*, iii., 237.

Limonite after Staurolite, from Ireland, the so-called Crucite, has been shown to be after mispickel.

Magnetite after Pyrites, from Tarbet, is recorded by Hall, but requires confirmation.

Malachite after Chalcopyrite is recorded by Greg and Lettsom, but without description or locality.

Malachite after Linarite, from Red Gill, Caldbeck, Cumberland. A specimen of altered linarite in the Jermyn Street Museum may be an example of conversion into Malachite.

Marcasite after Calcite. This pseudomorph is mentioned by Greg and Lettsom from the "Tamar mines, Beerferris, Devonshire, in low hexagonal prisms, slightly modified." There is a specimen in the Greg collection answering to this description, but labelled Cornwall; and there

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is no such specimen from Beerferris. It seems to be one of the pseudomorphs described above, under 28, as after pyrrhotite.

Marcasite after Dolomite, from Liskeard. A specimen in the British Museum may be a pseudomorph after dolomite.

Mica after Pinite is recorded by Greg and Lettsom, but without description or locality; there is no evidence that it differs from the nacrite after pinite, mentioned below.

Mispickel after Albite is recorded by Greg and Lettsom without description or locality, and as doubtful. Collins mentions a pseudomorph of pyrites after Albite, from the Consolidated Mines, without description.

Nacrite after Pinite is recorded by Greg and Lettsom, but without description or locality.

Plattnerite after Pyromorphite, from Leadhills; recorded as doubtful by Greg and Lettsom.

Prehnite after Quartz is recorded by Greg and Lettsom, but without description or locality.

Prehnite after Scolecite is recorded by Greg and Lettsom, but without description or locality.

Pyrites after Blende is recorded by Greg and Lettsom, without description or locality.

Pyrites after Chalybite is recorded by Collins, without description or locality.

Pyrites after Coal is recorded by Greg and Lettsom, without description or locality.

Pyrites after Galena is recorded by Greg and Lettsom, without description or locality.

Quartz after Anglesite is recorded by Greg and Lettsom, but without description or locality.

Quartz after Datolite, so called Haytorite, has been shown to be chalcedony after datolite.

Quartz after Felspar, from Boscagel Downs; recorded by Carne.

Quartz after Galena is recorded by Greg and Lettsom, but without description or locality.

Quartz after Hæmatite, from Huel Edward, is described as an epimorph by Carne; it is not quoted by Collins, and requires confirmation.

Quartz after Pyrites, from North Roskear, has been recorded by Carne (octahedral quartz); it is not quoted by Collins, and requires confirmation.

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Redruthite after Copper is recorded by Greg and Lettsom, without description or locality.

Salt after an unknown mineral is recorded by Collins (see the description by Ormerod).

Steatite after Barytes is recorded by Greg and Lettsom, but without description or locality.

Talcite after Andalusite, from Wicklow (?), is recorded by Hall.

Uranium-ochre after Uranite is recorded by Greg and Lettsom, but without description or locality.

Vanadinite after Hemimorphite is recorded by Greg and Lettsom, but without description or locality.

III. Preliminary list of British Pseudomorphs which may be regarded as established on fairly satisfactory evidence.

In this list the known existence of a specimen is recorded in preference to evidence which may be found in the literature; many occurrences are here accepted on the authority of a competent observer where the locality is definitely stated, even though not described.

Albite after Analcime, from Edinburgh and Kilpatrick; recorded by Greg and Lettsom.

Albite after Laumontite from Edinburgh; in the British Museum; recorded from Kilpatrick by Greg and Lettsom.

Albite after Stilbite, from Kilpatrick; in the British Museum.

Amphibole after Augite, from Wales; see Harker, *Min. Mag.* VIII. 32.

Analcime after Laumontite, from Kilmalcolm, Renfrewshire; in the British Museum.

Analcime after Prehnite, from Paisley, Renfrewshire; recorded by Hall.

Apatite after Cronstedtite, from Wheal Maudlin, Cornwall; see above, No. 1.

Barytes after Barytocalcite, from Alston; in the British Museum.

Barytes after Witherite, from Hexham and Dufton; in the British Museum; see Greg and Lettsom, and *Neues Jahrb. f. Min.* 1895, I. 252.

Bindheimite after Jamesonite, from Endellion, Cornwall; specimens of jamesonite in the British Museum are altered into a brown mineral, probably a mixture of various oxides of antimony as described by Brooke from Lostwithiel, and by Sillem.

Calamine after Fluor, from Derbyshire; in the British Museum.

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Calamine after Calcite, from Matlock, and from the Mendips; in the British Museum.

Calcite after Aragonite, from Eskett, Ennerdale, Cumberland. A specimen in the Ludlam collection, Jermyn Street Museum.

Calcite after Celestine (?), from Jarrow; see above, No. 8.

Calcite after Galena, from Wanlockhead; recorded by Greg and Lettsom.

Calcite after Leadhillite, from Leadhills; recorded by Greg and Lettsom.

Calcite after Quartz, from Cork; see above, No. 2.

Cassiterite after Felspar, from St. Agnes; well known in all collections; this replacement is also recorded from St. Austell by Collins; see *Min. Mag.* IV. pp. 8, 112.

Cassiterite after Quartz, from St. Agnes; the so-called stannite.

Cerussite after Anglesite, from Leadhills; in the British Museum; there is also a specimen from Derbyshire which may be after anglesite.

Cerussite after Galena, from Leadhills; in the British Museum; the replacement is also recorded from Cornwall by Carne.

Cerussite after Lanarkite, from Leadhills; see above, No. 4.

Cerussite after Leadhillite, from Leadhills; in the British Museum; the pseudomorph is a mixture of cerussite and pyromorphite.

Cervantite after Stibnite, from Eskdale; recorded by Hall.

Chalcedony after Barytes, from Cornwall; recorded by Greg and Lettsom.

Chalcedony after Datolite, from Haytor, Devonshire; well known as haytorite; also recorded from North Roskear mine by Greg and Lettsom.

Chalcedony after Calcite, from Liskeard, in Cornwall, and from Haytor, in Devonshire; both these localities are represented in the British Museum.

Chalcedony after Dolomite, from Penzance and Redruth, in Cornwall; in the British Museum.

Chalcedony (or Hornstone) after Fluor, from Menheniot, in Cornwall, and from Beeralston, in Devonshire; both these localities are represented in the British Museum; the latter are well known.

Chalcopyrite after Bismuthite, from Fowey, Cornwall, and Tavistock, Devonshire; see above, Nos. 6 and 7.

Chalcopyrite after Bournonite, from Liskeard; see above, No. 13.

Chalcopyrite after Calcite, from Cornwall; see above, No. 5.

Chalcopyrite after Redruthite, recorded by Greg and Lettsom; and by Collins from Cornwall; in the British Museum from St. Just.

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Chalcopyrite after Tetrahedrite, from Herodsfoot mine, Liskeard; these beautiful pseudomorphs due to superficial alteration are common in all collections. This replacement is recorded from the Levant mine by Greg and Lettsom; in the British Museum from St. Austell.

Chalybite after Barytes, from Virtuous Lady mine, Tavistock, Devonshire; these hollow epimorphs are familiar in all collections.

Chalybite after Bismuthite, from Fowey, Cornwall; see above, No. 8.

Chalybite after Calcite, from Marazion, Cornwall; in the British Museum; recorded from Beeralston, Devonshire, by Greg and Lettsom.

Chalybite after Dolomite, from Wheal Owles, St. Just, Cornwall; recorded by Collins.

Chalybite after Fluor, from Virtuous Lady mine, Tavistock, Devonshire; these hollow epimorphs are also well known, and are fully described by Blum; in the British Museum is also a specimen from Alston, Cumberland; and it is recorded from Wheal Maudlin, Cornwall, by Greg and Lettsom, and from Fowey by Hall.

Chalybite after Pyrites, from Devonshire; in the British Museum, and recorded by Greg and Lettsom.

Chlorite after Axinite, from Dartmoor: in the British Museum; described by Blum.

Chlorite after Felspar, and Magnetite, from Cornwall; recorded by Collins.

Chlorite after Mispickel, from Carn Brea, Cornwall; see above, No. 9.

Chrysocolla after Chalcophyllite, from Wheal Unity (?), Cornwall; a specimen in the Jermyn Street collection consists of hexagonal plates of chalcophyllite completely converted into chrysocolla.

Chrysocolla after Chalybite, from Roughten Gill, Cumberland; a specimen in the Jermyn Street collection appears to be rhombohedra {100} converted into chrysocolla.

Chrysocolla after Cuprite, from Cornwall; in the British Museum; these pseudomorphs generally consist of a mixture of chrysocolla and malachite; the best specimens are from Wheal Phœnix, Liskeard; they sometimes have globular phosphate of copper dispersed upon them.

Chrysocolla after Felspar, from Cornwall; Semmons, *Min. Mag.* II. 200.

Chrysocolla after Malachite, from Roughten Gill; a specimen in the Jermyn Street collection.

Copper after Cuprite, from Cornwall; see above, No. 10.

Covelline after Chalcopyrite, from Wheal Maudlin, Cornwall; recorded by Greg and Lettsom.

Covelline after Harrisite, from Wheal Falmouth; Davies, *Min. Mag.* I. 118.

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Dolomite after Calcite, from Cornwall, and from Beeralston and Tavistock, in Devonshire; in the British Museum.

Erubescite after Chalcopyrite, Cornwall; see above, No. 11.

Erubescite after Redruthite, from Redruth, Cornwall; recorded by Greg and Lettsom, but not by Collins; there are specimens in the British Museum; see the description in Blum. A specimen from Wheal Damsel in the Jermyn Street Museum appears to consist of a mixture of erubescite and copper pyrites.

Ferrite after Augite, from Scotland; see Heddle, *Min. Mag.* V. 28, VII. 134.

Fluor after Calcite, from Derbyshire; see above, No. 12.

Fluor after Quartz, from Trowlesworthy Tor, Devonshire; Bonney, *Min. Mag.* vi. 48.

Galena after Anglesite, from Derbyshire; see above, No. 14.

Galena after Bournonite, from Liskeard; see above, No. 13.

Galena after Pyromorphite, from Wheal Hope, Truro, Cornwall. These pseudomorphs (formerly known as "Blue Lead") are well-known

Gilbertite after Quartz, and Orthoclase, Cornwall; see Solly, *Min. Mag.* VII. 141; Collins, ii. 94.

Göthite after Pyrites, from the Restormel Mines, Cornwall; recorded by Collins.

Green-earth after Augite, and Calcite, from Kilpatrick; recorded by Hall and by Greg and Lettsom.

Hæmatite after Calcite, from Furness and Bristol; see above, Nos. 17, 18.

Hæmatite after Chalybite, from Cornwall; *Min. Mag.* ii. 94.

Hæmatite after Fluor, from Furness, Millom and Redruth; see above, Nos. 15, 22.

Hæmatite after Pyrites, from Cumberland and Devonshire; see above, No. 16.

Hemimorphite after Calcite, from Matlock, Derbyshire; recorded by Hall; see Allan's *Mineralogy*, p. 44.

Hemimorphite after Galena, from Wanlockhead; recorded by Greg and Lettsom.

Hemimorphite after Vanadinite, from Wanlockhead; recorded by Greg and Lettsom.

Kaolin after Felspar, from Cornwall.

Kyanite after Staurolite, from Wicklow, Ireland; recorded by Greg and Lettsom.

Laumontite after Analcime, from Kilpatrick, Dumbartonshire; in the British Museum.

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Limonite after Calcite, from Bristol; see above, No. 18.

Limonite after Chalybite, from St. Just, Cornwall; there is a specimen in the British Museum from Botallack mine; this occurrence is recorded by Carne; the same replacement is also recorded from Mawddach in Wales, see *Min. Mag.* III. 127.

Limonite after Cronstedtite, from Truro; see above, No. 20.

Limonite after Fluor, from Redruth; see above, No. 21.

Limonite after Garnet, from Belstone, Devonshire; recorded by Collins on the authority of Davies.

Limonite after Göthite, from Restormel, Lostwithiel, Cornwall; recorded by Greg and Lettsom.

Limonite after Hæmatite, from St. Just; see above, No. 22.

Limonite after Marcasite, from Dorset, Lewes in Sussex, Moneyash in Derbyshire, St. Just in Cornwall; specimens from all these localities are in the British Museum. The pseudomorph is recorded from Stromness, in the Orkney Islands, by Greg and Lettsom; see also *Min. Mag.* III. 224.

Limonite after Mispickel, from Clonmel, Co. Waterford, Ireland; the so-called "crucite" common in all collections.

Limonite after Pyrites, from Cornwall, and from Hoy, is recorded by Greg and Lettsom, by Carne and by Heddle.

Magnetite after Picrolite, from Scalpa, Hebrides; see above, No. 23.

Magnetite after Cerussite, from Redruth, Cornwall; see above, No. 24.

Malachite after Chalcophyllite, from Camborne, Cornwall; recorded by Semmons in *Min. Mag.* VI. 162.

Malachite after Cuprite, from Redruth, Cornwall; in the British Museum.

Marcasite after Barytes, from Tavistock, Devonshire; see above, No. 26.

Marcasite after Pyrrhotite, from Cornwall; see above, No. 28.

Nacrite after Andalusite, from Wicklow, Ireland; recorded by Greg and Lettsom; Hall calls it talcite.

Olivenite after Quartz, from Marke Valley mine, Liskeard, Cornwall; an epimorph in the British Museum.

Olivine after Sphene, from Sutherland; Heddle, *Min. Mag.* V. 189.

Pectolite after Analcime, from Edinburgh; in the British Museum.

Pinite after Cordierite, from Cornwall, Perth and Dublin; see Collins, *Min. Mag.* X. 8. There are specimens from Cornwall in the British Museum.

Plumbo-resinite after Barytes and Pyromorphite, from Roughton Gill, Cumberland; see above, No. 25.

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Prehnite after Analcime, from Hartfield, and from Kilpatrick; in the British Museum.

Prehnite after Pectolite, from Edinburgh; in the British Museum.

Pseudophite after Labradorite, from Aberdeen; Heddle, *Min. Mag.* III. 138.

Pyrites after Barytes, from Cornwall and Cumberland; see above, Nos. 26 and 27.

Pyrites after Calcite, from Herodsfoot mine, Liskeard, Cornwall; recorded by Collins; there is a specimen in the British Museum consisting of marcasite and pyrites. It is also recorded by Greg and Lettsom from Tavistock.

Pyrites after Fluor, from Alston, is mentioned by Greg and Lettsom, p. 280; from Cornwall, see above, No. 29.

Pyrites after Pyrrhotite, from Cornwall; see above, No. 28. A specimen in the Jermyn Street Museum is labelled Redruth.

Pyrites after Quartz, from Cornwall; see above, No. 29.

Pyromorphite after Barytes, from Leadhills; in the British Museum.

Pyromorphite after Galena, from Leadhills; in the British Museum.

Pryomorphite after Leadhillite, from Leadhills; in the British Museum (the pseudomorph is a mixture of pyromorphite and cerussite).

Quartz after Barytes, from Liskeard, from Devonshire, from Somerset, and from Durham; see above, Nos. 30, 31.

Quartz after Bournonite, from Liskeard; see above, No. 32.

Quartz after Calcite, from Gwennap, from Botallack mine in St. Ives, from East Pool Mine in Redruth, and from Bodmin, Cornwall (Fowey Consols, Jermyn Street Museum); from Clifton and from Haytor; specimens from some of these localities are in the British Museum, the others are recorded by Greg and Lettsom and by Hall. In a very perfect specimen from Wheal Alfred in the Jermyn Street Museum curved polysynthetic rhombohedra are completely replaced by clear quartz.

Quartz after Chalybite, from Redruth, Cornwall; there is a specimen in the British Museum; it is also recorded from Botallack mine by Carne.[1] From Cook's Kitchen mine (Ludlam collection).

Quartz after Dolomite, from St. Just, Cornwall, and from the Orkneys; recorded by Greg and Lettsom; from Trevartha (Ludlam collection).

Quartz after Fluor, from Wheal Alfred and Botallack mine, and from Caradon (Ludlam collection) in Cornwall, from Devonshire, from Alston, from Clifton, from Shropshire, and from Durham; some in the British Museum, and the others recorded by Greg and Lettsom, and by Hall.

[1] *Trans. Roy. Geol. Soc. Cornwall*, 1822, II. 307.

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Quartz after Orthoclase, from St. Austell, Cornwall; recorded by Collins; *Min. Mag.* i. 57.

Quartz after Silver, from Cornwall; see above, No. 33.

Quartz after Stilbite, from Kilpatrick (recorded by Greg and Lettsom), and from Dumbarton (in the British Museum). This seems to be a complete replacement of the mineral by quartz.

Redruthite after Galena, from Perran, Cornwall; see *Min. Mag.* Vol. I. p. 114. The specimen is in the British Museum.

Redruthite after Pyrites, from St. Just, Cornwall; see above, No. 19.

Redruthite after Erubescite, from Redruth, Cornwall; see No. 34.

Sandstone, Shale and Clay after Salt, from Cheshire; recorded by Greg and Lettsom.

Saponite after Calcite, from Derry, Ireland; recorded by Greg and Lettsom.

Scheelite after Wolfram, from East Pool mine, Cornwall; see Collins, *Min. Mag.* II. 92, and *Handbook to the Mineralogy of Cornwall and Devon.*

Serpentine after Pyroxene and Amphibole from Scotland; see Heddle, *Trans. Roy. Soc. Ed.* 28, pp. 491, 501, 530.

Steatite after Analcime, from Edinburgh; recorded by Greg and Lettsom.

Steatite after Faroelite, from Magee Island, Antrim; recorded by Hall.

Steatite after Felspar, from Wheal Coates, St. Agnes, Cornwall; in the British Museum.

Steatite after Pectolite, from Ratho, Edinburgh; in the British Museum; see Heddle, *Phil. Mag.* XVII. 46.

Tourmaline after Felspar, from Cornwall; recorded by Collins.

Vanadinite after Galena, from Wanlockhead; recorded by Greg and Lettsom.

Wad after Calcite, from Leadhills; recorded by Greg and Lettsom.

Witherite after Barytes, from Dufton; recorded by Greg and Lettsom.

Wolfram after Scheelite, from Wheal Maudlin; in the British Museum.

For fuller references to the literature, and for additional mines, see Collins, *Handbook to the Mineralogy of Cornwall and Devon*, p. 80, and Spencer, Index of Subjects, *Min. Mag.* Vols. I.-X. p. 65.

For a recent discussion of pseudomorphs of Calcite after Celestine or Gaylussite, see van Calker, *Zeits. f. Kryst.* (1897) 28, p. 560.

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The Identity of Andorite, Sundtite and Webnerite.

By G. T. Prior, M.A., F.G.S., and L. J. Spencer, M.A., F.G.S., Assistants in the Mineral Department of the British Museum.

[Read April 6th and June 17th, 1897.]

I. Historical and Introductory.
II. The British Museum Specimen of Andorite "from Hungary."
III. Krenner's Andorite.
IV. Brögger's "Sundtite."
V. Stelzner's "Webnerite."
VI. Other Specimens of Andorite from Oruro; Occurrence of Alunite.
VII. The Systematic Position and the Characters of Andorite.

I. Historical and Introductory.

ON November 14th, 1892, Prof. J. A. Krenner[1] read before the Hungarian Academy of Sciences an account of a new silver ore from Felsőbánya, to which he gave the name of Andorite. It was described as orthorhombic with $a : b : c = 0{\cdot}97756 : 1 : 0{\cdot}86995$, and as having the chemical composition $2PbS.Ag_2S.3Sb_2S_3$.

At a meeting of the Scientific Society of Christiania, held on December 9th of the same year, Prof. W. C. Brögger[2] gave a description, under the name of Sundtite, of a mineral from Oruro, Bolivia. An analysis by G. Thesen gave to it the formula $(Ag_2,Cu_2,Fe)S.Sb_2S_5$, while crystallographic measurements showed it to be orthorhombic with

$$a : b : c = 0{\cdot}677107 : 1 : 0{\cdot}445786.$$

The angular measurements agree completely with those of Krenner for Andorite; but, not being aware of this, Brögger chose different para-

[1] "Andorit, uj hazai ezüstérez." *Mathematikai és természettudományi Értesitő*, XI. 119-122, 1892. German abstracts of this paper ("Andorit, ein neues ungarisches Silbererz") are given by A. Schmidt in *Zeits. Kryst. Min.* XXIII. 497-499, 1894, and in *Földtani Közlöny*, XXV. 258-259, 1895.

[2] "Sundtit, et nyt mineral fra Oruro i Bolivia." *Forhandlinger i Videnskabs-Selskabet i Christiania*, for 1892, No. 18, 1893; and *Zeits. Kryst. Min.* XXI. 193-199, 1893.

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meters. The exact locality in Oruro of Brögger's Sundtite has been given by Dr. R. Pöhlmann[1] of Santiago as the Itos mine.

In 1894 the late Prof. A. W. Stelzner,[2] of Freiberg in Saxony, gave the results of an examination which had been made in 1889 of a mineral from the same mine at Oruro. An analysis by Dr. P. J. Mann gave to this mineral the formula $2\frac{1}{2}(PbS.Sb_2S_3)+Ag_2S.Sb_2S_3$, and accordingly it was described as an argentiferous zinckenite, for which the variety name of Webnerite was proposed. The crystals at Stelzner's disposal were not suitable for crystallographic determination, and the publication of his results was therefore deferred in the hope of better material being obtained. It was only when struck by the similarity in some of the characters of "Sundtite," as described by Pöhlmann, and the mineral he himself had examined, that he was induced to publish his paper, and in it to throw out the suggestion that some of the "Sundtite" described by Pöhlmann might possibly be "Webnerite."

Krenner's paper on Andorite appears to have escaped the notice of Stelzner, otherwise he would have observed that "Webnerite" has essentially the same chemical composition as Andorite.

In the present paper it will be shown:

1. That Andorite, Sundtite and Webnerite, which have been independently described as distinct mineral species, are in fact identical.
2. That Krenner's determination is the correct one for the species.
3. That "Sundtite" was correctly described crystallographically, but wrongly chemically.
4. That "Webnerite," in being called an argentiferous zinckenite, was incorrectly placed crystallographically, though accurately determined chemically.

In such a case it is clear that the slightly older name Andorite is the only one that can be retained for the species.

The identity in the first place of "Sundtite" and "Webnerite" was suggested to us by the examination of a specimen "from Hungary" in the British Museum collection, which, on examination, was found to have the chemical composition of "Webnerite," but the crystallographic characters of "Sundtite." A re-examination, therefore, of the original material described by Brögger and Stelzner appeared to be necessary, and through the kindness of Prof. Brögger on the one hand, and Prof.

[1] "Notizen über Sundtit von Oruro in Bolivia." *Zeits. Kryst. Min.* XXIV. 124-125, 1894.

[2] "Bemerkungen über Zinckenite von Oruro in Bolivia." *Zeits. Kryst. Min.* XXIV. 125-127, 1894.

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Weisbach on the other, this was rendered possible. The result of our examination of these specimens was to show that both were identical with the specimen "from Hungary." It was not until we had completed this work that we happened to notice Krenner's paper, and saw that the mineral "from Hungary" was a specimen of Andorite, and that consequently Andorite, "Sundtite" and "Webnerite" were identical.

II. The British Museum Specimen of Andorite "from Hungary."

The small specimen on which the mineral was found consists of a fragment of argillaceous rock, veined with quartz and pyrites, and containing a few minute cubes of the latter mineral. On one side is a bed of white quartz with a crystallised surface, and on this are distributed a few small crystals of Andorite. Some of these crystals rest only on the apices of the quartz crystals with scarcely any point of attachment, in which case they are completely and symmetrically developed on all sides, while others are more firmly attached and intergrown in the matrix. On the free surface of the specimen the following crystallised minerals were also found, but only in very small amount. Fluorite in minute colourless cubes with small $m\{311\}$ occurs in small groups with yellowish siderite. In one or two cavities are a few delicate hairs having the appearance of the plumosite variety of jamesonite. The fluorite contains a few black acicular enclosures, possibly of the same mineral. Mispickel is represented by one or two very minute prismatic crystals. A few specks of copper pyrites were found, in one case enclosed in Andorite. Lastly, a few minute hexagonal plates may possibly be referred to stephanite. All these minerals are of later formation than the Andorite, which is itself later than the quartz.

All the information we possess as to the locality of the specimen is that it was entered in the Museum register in 1861 as from Hungary; but this locality may possibly have been ascribed to it only because it was then thought to be freieslebenite.

The Andorite crystals are 1—3 mm. in length, have a dull black, often drusy surface, and are much striated and rounded, but are always symmetrically developed. All the crystals have the same short prismatic habit (fig. 1, p. 294), which closely resembles that of freieslebenite. Only rarely is seen a bright surface with a steel-grey colour and metallic lustre. The fracture is smooth and conchoidal, with a curious strong metallic lustre (rather like that sometimes shown by crystals of tetra-

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hedrite and bournonite), and an iron-black or dark steel-grey colour. There is no cleavage. The mineral is opaque, brittle, and easily crushed to powder. The streak is black and shining, but the fine powder is dull. The hardness is a little over 3, as the mineral scratches calcite with difficulty, and is itself easily abraded when rubbed on fluorite.

The density (weight of 1 cc.) is 5·33, at 19° C. as determined on 0·2152 gram of the material collected for analysis.

Crystallographic Characters (L.J.S.).—Orthorhombic,[1] with the forms :—

$a\{100\}$, $b\{010\}$, $n\{210\}$, $i\{430\}$, $m\{110\}$,
$l\{230\}$, $k\{120\}$, $y\{031\}$, $t\{091\}$.

Brögger's parameters and letters are here used. The following results were obtained from the measurement of 17 crystals and fragments with the δ eye-piece of the Fuess goniometer.

	Limits of measured angles.	No. of edges.	Mean.	Calculated (Brögger).	Measured (Krenner).
$ba = 010 : 100$	88° −92°	17	90° 6′	90° 0′	90°0′
$bn = 010 : 210$	69½° −74°	36	72° 2½′	71°18′	—
$bi = 010 : 430$	61° −67°	6	63°53′	63° 5′	—
$bm = 010 : 110$	55°13′ −59°11′	35	56°13′	55°54′	55°32′
$bl = 010 : 230$	42¾° −46°54′	37	45° 0½′	44°33′	44°21′
$bk = 010 : 120$	34°54′ −37°58′	12	36° 8½′	36°27′	36°28′
$by = 010 : 031$	35° −41°	29	37°58½′	36°47½′	36°58′
$yy' = 031 : 03\bar{1}$	75°26′ −77°	9	75°59′	73°35′	—
$bt = 010 : 091$	13°16′ −15°26′	4	14° 8′	14° 0′	—
$ya = 031 : 100$	90° about	3	90° 0′	90° 0′	—
$yn = 031 : 210$	75° −76°	8	75°30′	75° 7′	—
$ym = 031 : 110$	62½° −64°40′	5	63°23′	63°19′	—
$yl = 031 : 230$	55° −56½°	4	55°30′	55°12′	—
$yk = 031 : 120$	49½° −49°33′	2	49°31′	49°53½′	—

The faces of the crystals are so rough that only approximate measurements could be obtained. The macropinacoid and prisms are rounded and very deeply striated parallel to the vertical axis, so that between k (120) and $k(1\bar{2}0)$ there is a continuous band of images, with brighter portions at the positions of $a\ n\ i\ m\ l\ k$; between k and b there are no images.

[1] Before the idea of the identity of the mineral with Sundtite and Andorite had been entertained, the axial ratios were deduced from the angles $bn = 72°2\frac{1}{2}'$ and $by = 37°58\frac{1}{2}'$, as $a : b : c = 0·324 : 1 : 1·281$.

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The faces of the form $y\{031\}$ are very rough, having a pitted and drusy surface, so that generally only maximum light readings could be obtained. The faces of the form $b\{010\}$ are often brighter, but are striated and rounded horizontally; they are sometimes represented by two or more distinct planes forming a very obtuse salient or re-entrant angle, and several images were seen at 3° to 9° from the true position of b in the zone [100]; this could not be made to agree with any twinning on the assumption that the crystals were monosymmetric.

The habit of the crystals, which is remarkably constant and symmetrical, is shown in fig. 1 (p. 294). In the figure the prisms have been drawn as distinct faces, but on the actual crystals this is only sometimes the case, and then only with k and l. Not infrequently two crystals are intergrown, but no twin law could be discovered.

Chemical Composition (G. T. P.).—As the total amount of material on the single specimen was very limited, only 0·2073 gram was available for analysis. This consisted for the most part of measured crystals, from which the drusy material on the y (031) faces was scraped off as far as possible.[1] The mineral is easily fusible, and is decomposed by hydrochloric acid.

In the quantitative analysis, the finely powdered mineral, dried at 100° C., was weighed into a porcelain boat, and decomposed in a current of chlorine. Only a gentle heat, with a spirit lamp alone, was applied, so that no volatilisation of lead chloride or ferric chloride occurred. After the decomposition in chlorine, the non-volatile chlorides were transferred to a porcelain dish and digested with boiling water, to which a little nitric acid was added. The silver chloride was filtered off, and the filtrate was evaporated down with sulphuric acid; alcohol was then added, and the lead weighed as lead sulphate. In the filtrate the copper was precipitated by sulphuretted hydrogen, and then the iron, after oxidising with bromine water, with ammonia.

The volatile chlorides were absorbed by water containing hydrochloric and tartaric acids. The solution was transferred to a beaker and warmed gently for some time to expel the chlorine. The sulphur was then precipitated as barium sulphate. The filtrate was evaporated down to expel excess of acid and the slight precipitate obtained on dilution added to the rest of the barium sulphate, which was afterwards purified by digestion in hydrochloric acid in the usual manner. In the filtrate the excess of

[1] This drusy material sometimes showed hexagonal outlines under the microscope, and it is possibly the same mineral as that referred to stephanite above.

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barium was removed by means of sulphuric acid. The antimony was then precipitated by sulphuretted hydrogen, and, after washing with alcohol and carbon bisulphide and heating to 260°-270° in a current of carbon dioxide, was weighed as trisulphide. The filtrate from the sulphide of antimony contained scarcely a trace of iron.

The mineral was tested for arsenic by the Fresenius-Babo method, but with negative result.

The results of this analysis, given in Column I below, agree with the formula $2PbS.Ag_2S.3Sb_2S_3$ (see IX p. 298).

	I.	II.		III.
Pb ...	21·81	0·923		22·07
Ag ...	11·73	0·943	1·042	11·31
Cu ...	0·73	0·099		0·69
Fe ...	1·45	0·022		0·70
Sb ...	41·76	3·002		41·91
S ...	22·19	6·000		23·32
Insoluble ...	—			0·04
	99·67			100·04

I. The present analysis of Andorite "from Hungary," made on 0·2073 gram.

II. The atomic ratios of the same with S=6.

III. J. Loczka's analysis of Krenner's Andorite from Felsőbánya, Hungary. The 0·70 per cent. of iron includes some zinc and manganese.

The close agreement in the measured angles and in the chemical composition shows the identity of our mineral with Krenner's Andorite.

The above description was written before we had read Krenner's paper. We have preferred to leave it in its original form, since the locality of our specimen is somewhat doubtful, and the associated minerals are not the same as those on Krenner's material.

III. Krenner's Andorite.

Krenner's description of the characters of Andorite is in close agreement with the preceding description of the British Museum specimen.

The only important difference is the good cleavage parallel to $b(010)$[1]

[1] $=a(100)$ of Krenner.

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noted by him. We have not seen the material described by Krenner, but no cleavage is shown by any of the Andorite ("Sundtite" and "Webnerite") specimens which we have examined. It may, however, be mentioned that while measuring our crystals, indistinct images were sometimes obtained from small points or irregular fractures in approximately the positions of $c(001)$ and $b(010)$, which may indicate the existence of imperfect cleavages in these directions. Krenner gives the fracture as uneven, and does not mention the characteristic conchoidal fracture. The specific gravity in the original paper is stated to be 5·541, but in the abstracts by Schmidt it is given as 5·341, which is very close to the value obtained by us. The analysis published by Krenner is quoted in Column III above.

With Brögger's position of the crystals and parametral plane, Krenner's[1] measured angles $bl = 44°21'0''$ and $bx = 66°0'46''$ give the axial ratios $a : b : c = 0{\cdot}68197 : 1 : 0{\cdot}44496$, and his forms will then be—

$a\{100\}$, $b\{010\}$, $m\{110\}$, $l\{230\}$, $k\{120\}$, $u\{130\}$
$\{x011\}$, $\gamma\{021\}$, $y\{031\}$, $q\{221\}$, $r\{121\}$, $\beta\{131\}$.

Of these forms, $u\{130\}$ [$=n\{210\}$ of Krenner] is not elsewhere recorded.

Brögger's parameters and letters for the forms are the ones here adopted, since his measurements are the more accurate.

IV. Brögger's "Sundtite."

In presenting to the Museum, and thus with great liberality placing at our disposal, about half of the original crystallised material, Prof. Brögger states that Thesen's analysis was not made on the actual material which was measured, and that it is therefore possible that the crystals have not the composition assigned to them by that analysis.

The four small fragments which we have examined consist of an aggregate of bright, well-developed crystals of Andorite and pyrites, the latter being mostly of earlier formation. Scattered over both of these, and partly embedded in them, are small crystals of pyrites; and later still are minute globules of a yellow incrusting mineral, which sometimes completely coats the surfaces of the crystals.[2] There are also a few small aggregates of an

[1] Krenner interchanges $a\{100\}$ and $b\{010\}$; his parametral plane would be (463), which is not an observed form.

[2] The amount of this was too small to make a satisfactory determination of the chemical composition possible. Pöhlmann mentions antimony oxide as a yellow powder dusted over the crystals.

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orange-red coloured mineral, and a few black needles with a metallic lustre; similar needles are called stibnite by Brögger, jamesonite by Pöhlmann, and zinckenite by Stelzner, whose determination is based on an analysis. The larger and earlier crystals of pyrites are octahedral in habit, with small cube, $a\{100\}$, and pyritohedral, $\pi e\{210\}$, planes, and are of interest as apparently showing, in addition to the direct form, $é\{210\}$, the inverse form, $e\{120\}$, together with what is apparently the rhombic dodecahedron, $d\{110\}$; but when the crystals are placed on the goniometer, these are seen to be due to frequent oscillations between $a(100)$ and $é(210)$. The smaller crystals of pyrites have a rather different habit, being cubes or cubo-octahedra with small $\pi e\{210\}$.

The Andorite crystals are, as described by Brögger, very bright and rich in faces. The habit is somewhat varied; some of the crystals are thick-tabular parallel to the orthopinacoid $a(100)$, as in Brögger's figure, others are of the same habit as the Hungarian crystals (fig. 1, p. 294), and some have the pyramids in the zone [110, 001] largely developed, as shown in fig. 2. The basal plane is comparatively rare, and, when present, is usually quite small, so that the habit shown in fig. 2 is rather exceptional. The mineral has a steel-grey colour with bright metallic lustre; the powder is black and dull. It is very brittle, and has a smooth conchoidal fracture; it scratches calcite with difficulty. The density (weight of 1 cc.), determined on 0·4778 gram of the material used for analysis, was found to be 5·377 at 20° C.

The following crystallographic determinations were made on the material which was collected for the analysis; most of the fragments which showed crystal faces being measured in order to make certain of the identification of the mineral. The best crystals were not measured, but left intact on the specimens to represent the mineral in the collection; it is therefore probable, as pointed out by Brögger, who measured two crystals, that future measurements will add considerably to the list of forms. On the 15 crystals and fragments so measured the following 37 forms were detected:—

Pinacoids.	Prisms.	Macrodomes.	Brachydomes.	Pyramids.	
a 100	ϕ 610	h 102	x 011	v 112	δ 364
b 010	ψ 510	θ 305	ν 043	χ 223	r 121
c 001	n 210	σ 203	π 032	ρ 111	ε 362
	o 320	κ 405	γ 021	z 332	ω 132
	m 110	f 101	y 031	q 221	β 131
	l 230	e 302		ρ 331	α 162
	k 120	λ 301			ζ 2.21.7
		μ 902			s 211

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Brögger's $g\{250\}$ and $d\{601\}$, and the Hungarian forms $i\{430\}$, $u\{130\}$ and $l\{091\}$ were not observed on these crystals. With these the total number of forms which have been observed on Andorite is 42.

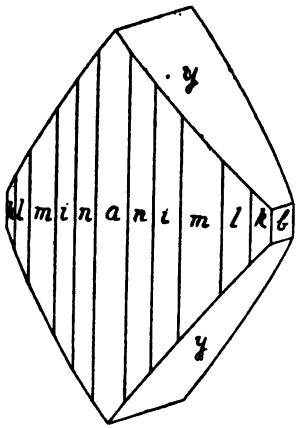

Fig. 1.

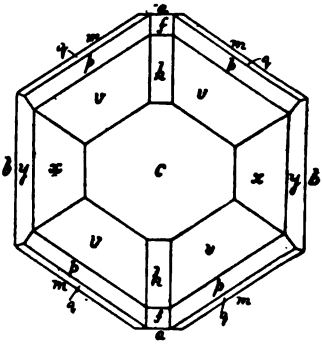

Fig. 2.

The individual crystals showed the following forms:—

1. abc, $nmlk$, hf, $x\gamma y$, vqp, $r\omega\beta a$. A rough, unsymmetrical crystal; the basal plane is a mere point.

2. bc, $h\theta\sigma f$, $x\pi\gamma y$, $v\chi pq$, $\delta r\epsilon\omega\beta\zeta$. This crystal is represented in fig. 2; it is only a fragment off the top of a small crystal.

3. ab, $nmlk$, $x\pi\gamma y$, and small pyramidal planes: habit as in fig. 1.

4. a, nml, fe, $x\gamma y$, $r\chi pq$, rs. An unsymmetrical crystal with a large r plane.

5. ab, nml, $x\nu\pi y$, and pyramids.

6. ab, nml, $x\pi y$, pzq.

7. ab, nml, $h\sigma\kappa fe\lambda\mu$, xy, vpq, $\delta r\omega\beta s$. Like fig. 2 without the basal plane.

8. ab, ψnom, $h\sigma fe\lambda\mu$, and pyramids.

9. c, m, he, y, $vpqp$, ωs, &c. Like fig. 2, but with the basal plane very small.

10. ab, ϕnm, y, and pyramids.

11 and 12. ab, $nmlk$, and brachydomes. Fig. 1.

13. ab, nml. 14. a, nm. 15. a, u.

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The measured angles establishing the new forms are:—

	Calculated (Brögger).	Measured (L. J. Spencer).
$a : \phi(610)$	6° 26′	6°51′. A narrow plane on crystal No. 10.
$a : \psi(510)$	7 48	7°35′. Narrow plane on No. 8.
$a : o(320)$	24 17½	23°, 24°. Striæ on No. 8.
$a : \theta(305)$	68 27	[21°26′], [22°]. Very small on No. 2.
$a : \sigma(203)$	66 18	66°42′, 67°, [23°]. Narrow plane and striæ on Nos. 2, 7 and 8.
$a : \kappa(405)$	62 13½	61°59′. Narrow plane on No. 7.
$a : \lambda(301)$	26 51	27°10′, 26°54′, 27°. Narrow planes on Nos. 7 and 8.
$a : \mu(902)$	18 29	18°35′, 18½°. Narrow plane and striæ on Nos. 7 and 8.
$b : \nu(043)$	59 16½	59°30′. Striæ on No. 5.
$b : \pi(032)$	56 14	56°14′, 57°, [33°19′], [33½°]. Striæ on Nos. 2, 3, 5 and 6.
$c : \chi(223)$	27 55½	27°45′. Narrow planes on Nos. 2 and 4.
$m : \rho(331)$	22 45	22°52′, 22½°. Narrow planes and spots on Nos. 1 and 9.
$c : \delta(364)$	39 44	39°26′, 40°. $\pi\delta = 22°17′, 22¼°$ (calculated 22°16′). On Nos. 2 and 7.
$c : \varepsilon(362)$	58 58	59°5′. $y_\varepsilon = 30°37′$ (calculated 30°31′). On No. 2.
$h : a(162)$	51 47½	51°49′. On No. 1.
$y : \zeta(2.21.7)$	6 26	6°23′. A narrow plane between $\beta(131)$ and $y(031)$. On No. 2.

In the above list, the angles are enclosed in square brackets when the measured angle is the complement of the given calculated angle. The new pyramids $\delta\varepsilon a\zeta$ are represented by very small, bright, unstriated planes, giving sharp images, and several good measurements were obtained besides those given above; they lie in several zones on the crystals, e.g. [120, 001], [100, 032], [100, 031], [010, 102] etc., as is shown on the stereographic projection, fig. 3.[1]

[1] On this projection all the forms of Andorite, with the exception of $u\{130\}$, are represented.

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Most of the forms noted by Brögger are present as well-developed planes, giving measured angles closely agreeing with the calculated values. Some of the best measurements obtained are—

	Calculated (Brögger).	Measured (Brögger).	Calculated (Krenner).	Measured (L. J. Spencer).
$v v' = 112 : 1\bar{1}2$	*23°54½′	*23°54½′	23°53′	23°56′, 23°59½′, 24°3′
$v v'' = 112 : \bar{1}\bar{1}2$	43 32	—	43 6	43 25
$h h' = 102 : \bar{1}02$	36 26½	36 28	36 8	36 33
$x x' = 011 : 0\bar{1}1$	48 3	48 1½	47 58½	48 1, 47°58′

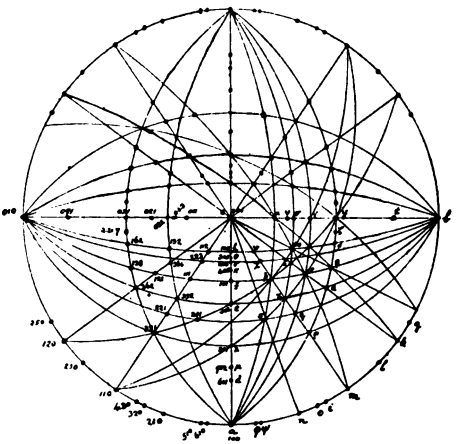

FIG. 3.

With the exception of Nos. 2 and 9, all the above crystals were used for the analysis, and in the collection of more material the characteristic bright conchoidal fracture of the mineral was relied upon. As far as could be seen the only impurities present in the material collected were minute crystals of iron pyrites, which were scattered like dust throughout the Andorite crystals, and so small that they were only visible under the microscope or with a high-power lens; two or three sharp bright cubo-octahedra of pyrites were large enough to be picked out. That this impurity could have been only small in amount is seen by the low percentage of iron shown in the analysis. The methods adopted in the analysis were the same as those described on p. 290. The results given in Column IV below agree closely with the formula $2PbS.Ag_2S.3Sb_2S_3$; thus proving the identity of "Sundtite" with the Hungarian mineral.

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		IV.	V.		VI.
Pb	...	24·10	1·013		trace
Ag	...	10·94	0·879	0·975	11·81
Cu	...	0·68	0·096		1·49
Fe	...	0·30	0·043		6·58
Sb	...	41·31	2·990		45·03
S	...	22·06	6·000		35·89
		99·39			100·80

IV. The present analysis of Brögger's "Sundtite" from Oruro, made on 0·4956 gram (G. T. Prior). No trace of arsenic was detected by the Fresenius-Babo test.

V. The atomic ratios of the same with S = 6.

VI. G. Thesen's analysis, which was given by Brögger as representing the composition of "Sundtite." In the original paper no details are given as to the methods of analysis or of the material used; but, as stated above, Prof. Brögger has informed us that the analysis was not made on measured crystals, and that the material handed over for chemical investigation was all used up in the analysis. The specific gravity of 5·50 was determined on this material. Under these circumstances it is useless to criticise the results, but it may be suggested that the iron was present as pyrites.

V. Stelzner's "Webnerite."

The specimen kindly presented to the British Museum by Prof. A. Weisbach consists of one of the indistinct crystals from Stelzner's original specimen in the collection of the Berg-Akademie at Freiberg. The smooth conchoidal fracture with strong metallic lustre, and the other characters which could be directly observed are in agreement with those of the Hungarian mineral. The striated zone of prisms gave a continuous band of images with brighter parts corresponding to the positions of $a(100)$, $n(210)$ and $i(430)$, as is shown by the following rough measurements:—

	Calculated.	Measured (L. J. S.).
$an = 100 : 210$	18°42′	16½°, 17°, 18°
$ai = 100 : 430$	26°55′	27°, 27°, 27¼°

Rough faces of the form $y\{031\}$ also seem to be present.

These crystallographic measurements, when considered in connection

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with the chemical composition as quoted in Column VII below, are enough to show that "Webnerite" is identical with Brögger's "Sundtite" from the same locality, and with Andorite.

Stelzner gave to "Webnerite" the formula $2\frac{1}{2}(PbS.Sb_2S_3) + Ag_2S.Sb_2S_3$. But, as shown below, when the copper is taken as replacing silver, and when the iron is considered to be present as pyrites, the numbers obtained in the analysis agree just as closely with the simpler formula $2(PbS.Sb_2S_3) + Ag_2S.Sb_2S_3$.

		VII.	VIII.		IX.	X.
Pb	...	24·30	1·004		23·81	25·53
Ag	...	10·25	0·812	0·900	12·42	10·65
Cu	...	0·65	0·088		—	—
Fe	...	0·53	—		—	—
Sb	...	40·86	2·896		41·63	41·66
S		23·10	6·000		22·14	22·16
		99·69			100·00	100·00

VII. P. J. Mann's analysis of Stelzner's "Webnerite" from Itos mine, Oruro, Bolivia.

VIII. The atomic ratios of the same with S = 6, after deducting iron and the corresponding amount of sulphur, as pyrites, FeS_2.

IX. The calculated percentage composition of $2PbS.Ag_2S.3Sb_2S_3$.

X. The calculated percentage composition of $2\frac{1}{2}(PbS.Sb_2S_3) + Ag_2S.Sb_2S_3$.

VI. Other Specimens of Andorite from Oruro; Occurrence of Alunite.

In the British Museum are two other specimens of Andorite from Oruro, which may be described here. One of these is labelled "Sundtit, Mina Itos, Oruro," by T. Hohmann of Valparaiso, by whom it was sent to Europe, his authority for the locality being Pöhlmann's paper. This shows rather indistinct crystals of Andorite, of the habit represented in fig. 1, with cubo-octahedra of pyrites, on a matrix of decomposing massive pyrites and quartz. Some of the massive Andorite is mixed with pyrites, and does not seem to be very pure. There is a small radiated group of acicular crystals which may be jamesonite, zinckenite, or stibnite.

White crystalline *alunite* occurs, coating parts of this specimen. It consists generally of a loose aggregate of minute crystals, but in places

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it is more compact. This occurrence of alunite is very similar to that recently described by E. B. Hurlburt[1] from the National Belle mine, Red Mountain, Ouray Co., Colorado. Under the microscope the material is seen to consist wholly of sharply developed crystals rather more than 0·01 mm. in diameter. Each crystal consists of a rhombohedron truncated by the basal planes as in Hurlburt's figure, but here the basal planes are always triangles and the outlines of the crystals are hexagons. When the crystals rest on a basal plane they are isotropic, but they are too small to give an interference figure in convergent polarised light. The chemical reactions were in agreement with alunite, which is a hydrated basic sulphate of aluminium and potassium. The mineral gave a good potassium flame which was not masked by sodium, as would be the case with the Red Mountain material in which half the potassium is replaced by sodium. Coating some of these crystals, as well as other parts of the specimen, is a cherry-red powder, which, as it contains iron, is probably turgite. It was possibly formed, together with the alunite, by the decomposition of the pyrites.

The second specimen is labelled "Zinckenit,[2] Socavon de la Virgen, Oruro." In a cavity at the back of the specimen is a small amount of Andorite, as shown by qualitative chemical analysis and the measurement of crystal fragments. Besides pyrites and quartz, there are also crystals of kaolin, cassiterite, both massive and in minute crystals of a pale yellowish colour, and a little alunite. No tetrahedrite was seen on this specimen. The prismatic crystals of cassiterite are about ¼ mm. in length, and show the forms $m\{110\}$ and $s\{111\}$; the measured angles varied only slightly from the mean value $ms^3 = 46°48'$. The massive cassiterite was tested for germanium, but with negative results. The minute alunite crystals are similar to those described above, but here the basal planes are smaller, so that the crystals have the appearance of cubes; the forms present are therefore $r(100)$ and $c(111)$. The most striking mineral on this specimen is the coarsely acicular "zinckenite;" with it is a more finely acicular mineral with the felted appearance of "feather ore."

This occurrence of Andorite at the Socavon de la Virgen (= Virgin level) shows that the Itos mine is not the only mine at Oruro in which the mineral is found. It is therefore not absolutely certain that Brögger's specimen came from the Itos mine, as stated by Pöhlmann.

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[1] *Amer. Journ. Sci.* 1894, XLVIII. p. 130.

[2] This may possibly be jamesonite.

[3] Dana gives $ms = 46°26\frac{2}{3}'$, and Miller 46°26'.

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The silver mines of Oruro have been described by H. Reck,[1] A. Webner,[2] formerly of the Itos mine, Weiner,[3] and A. W. Stelzner.[4] They form a group of mines in the hill on the west side of the town of Oruro, which is the capital of the department Oruro. It would seem that Andorite is one of the principal silver ores of these lodes, which are some of the most important in South America, and were worked by the Indians previous to their discovery by the Spaniards in the sixteenth century.

VII. The Systematic Position and the Characters of Andorite.

The formula of Andorite ($2PbS.Ag_2S.3Sb_2S_3$) resembles that of zinckenite ($PbS.Sb_2S_3$) in representing a metasulph-antimonite, and as both zinckenite and Andorite are orthorhombic, it might be expected that there would be some crystallographic relationship between them. The only angles, however, which can be compared are not at all close. In the elongated and striated zones there is an approach to angles of 60°, but this is shown by Penfield[5] to be the case with many sulpho-salts.

Sundtite.		Zinckenite.	
$am = 100 : 110$	34° 6′	$c\varepsilon = 001 : 102$	29°40½′
$ch = 001 : 102$	18°13¼′	$bk = 010 : 061$	14°42′

As there is also no crystallographic relation between Andorite and the monosymmetric miargyrite ($Ag_2S.Sb_2S_3$), it may be concluded that in Andorite the lead and silver do not isomorphously replace each other, but that we have here a definite double salt with the composition $2(PbS.Sb_2S_3) + Ag_2S.Sb_2S_3$. The cubic brongniartite ($Ag_2S.PbS.Sb_2S_3$) also seems to be a double salt which is related in a similar manner to the orthorhombic jamesonite ($2PbS.Sb_2S_3$), though there is here nothing to correspond to miargyrite. Amongst well-determined minerals, other double salts are freieslebenite and diaphorite, bournonite and aikinite: and in the whole range of the sulpho-salts, with the exception of tetrahedrite-tennantite and polybasite-pearceite, isomorphous replacement seems to

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[1] *Petermann's Geograph. Mitth.* 1867, p. 319.

[2] *Berg- und Hüttenm. Zeit.* 1887, p. 157; 1888, pp. 241 and 263.

[3] *Annales des Mines* 1894, Ser. 9, V. Mem. p. 511, with map.

[4] *Zeits. deutsch. geol. Ges.* 1897, XLIX. pp. 82, 126. See also F. de Castelnau, *Expédition Amerique du Sud*, 1851, III. 358.

[5] *Amer. Journ. Sci.* 1896, [4] II. p. 28; and *Zeits. Kryst. Min.* 1896, XXVII. p. 76.

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take place only to a limited extent, and when two bases occur together in larger quantity double salts are formed.

Summary of the Characters of Andorite.

Orthorhombic.—$a : b : c = 0{\cdot}6771 : 1 : 0{\cdot}4458$.

$100 : 110 = 34°6'$, $001 : 101 = 33°21\frac{1}{2}'$, $001 : 011 = 24°1\frac{1}{2}'$.

A list of forms is given on pp. 293-4.

Colour, dark steel-grey; brilliant metallic lustre; opaque.

Streak, black and shining; powder dull.

No cleavage; fracture smooth and conchoidal. Brittle.

Specific gravity 5·35. Hardness $3\frac{1}{4}$.

Composition, $2PbS.Ag_2S.3Sb_2S_3 = PbAgSb_3S_6$.

Localities: Felsőbánya, Hungary; the silver-tin mines at Oruro, Dept. Oruro, Bolivia.

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On Tripuhyite, a new Antimonate of Iron, from Tripuhy, Brazil.

By Dr. E. Hussak, of the Geological Survey of S. Paulo; and

G. T. Prior, M.A., F.G.S., Assistant in the Mineral Department of the British Museum.

[Read June 17th, 1897.]

THIS new antimonate was found in the cinnabar-bearing gravel of Tripuhy, Minas Geraes, Brazil. The minerals associated with it in the gravel, including the two new titano-antimonates lewisite and derbylite, have already been described in this Magazine (Vol. XI. No. 50, p. 80, and No. 52, p. 176). The original source of the lewisite and derbylite has been proved to be the muscovite-schists accompanying itabirite in the neighbourhood of Tripuhy. From these schists, doubtless, is also derived the tripuhyite, although as yet this new mineral has only been found in fragments loose in the gravel, and not intergrown with fragments of the muscovite-schists as is often the case with both lewisite and derbylite.

Physical Characters.

The mineral does not occur in the gravel in crystals, but only in microcrystalline aggregates of a dull greenish-yellow colour. Examined in thin sections under the microscope, these are seen to consist of translucent, highly refractive and strongly doubly-refracting grains. Observation in convergent light, with the help of a Czapski eye-piece, showed that the mineral was biaxial, but the individual grains were too small to allow of more exact determinations. Under a $\frac{1}{12}$th immersion objective, a lightly crushed fragment was seen to consist almost wholly of crystalline doubly-refracting, non-pleochroic, material of a bright canary-yellow colour, which appeared to be fairly homogeneous, as the only impurity observed consisted of a few minute flakes of a colourless doubly-refracting mineral, most probably muscovite. The streak is canary-yellow.

The specific gravity (weight of 1 cc.) was 5·82 at 19° C., as determined on 0·3035 gram.

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Chemical Characters (G. T. P.).

The mineral gave off no water when heated in the closed tube. In the Bunsen flame it was infusible, but blackened and gave off fumes colouring the flame pale greyish blue (Sb), and left finally a residue consisting mainly of red ferric oxide. It was insoluble in hydrochloric and nitric acids. Qualitative examination showed the presence of antimony and iron, with only traces of titanium and calcium.

For the quantitative analysis only 0·2475 gram was available. The mineral was decomposed by heating in hydrogen, and the analysis conducted as in the case of lewisite and derbylite (*loc. cit.*).

The numbers obtained were as follows :—

		Molecular ratios.
Sb_2O_5	= 66·68	·208
FeO	= 27·70	·385
CaO	= 0·82	·014
SiO_2	= 1·35	·023
Al_2O_3	= 1·40	·014
TiO_2	= 0·86	·010
Undet. (Alkalies ?)	= (1·19)	
	100·00	

The amount of material available for chemical investigation was not sufficient to allow of experiments to determine the state of oxidation of the iron. If the iron be considered, as above, to be in the ferrous state, the numbers obtained in the analysis agree approximately with the formula $2FeO.Sb_2O_5$.

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Monazite and Xenotime in European Rocks.

By Orville A. Derby, F.G.S., of the Geological Survey of S. Paulo, Brazil.

(Communicated by the General Secretary.)

[Read June 17th, 1897.]

As the phosphates of the cerium and yttrium groups, monazite and xenotime, have proved to be quite widespread microscopic accessories in certain types of Brazilian granites and gneisses, a *batea* test has recently been made on a number of hand specimens obtained from the mineral establishment of Dr. F. Krantz, of Bonn, for the purpose of determining if these interesting minerals were equally characteristic of the corresponding types of European rocks. About half of an ordinary museum specimen was crushed in a porcelain mortar to pass through a moderately fine sieve, concentrated in the batea and examined under the microscope after cleaning with the Thoulet or Klein solution, or both, and, when necessary, with the electro-magnet. The identifications of the minerals in the residues thus obtained, especially in cases of doubt, have been kindly revised by Dr. Eugen Hussak.

In making the selection for examination, attention was mainly directed to kaolins of granitic origin, pegmatites, muscovite and muscovite-biotite granites and gneisses, experience in Brazil having shown that negative results might usually be expected from rocks of a more basic character, though one of the minerals in question, monazite, has proved to be a quite common accessory in the purely biotite granites and gneisses as well. In a number of cases the residue obtained was so small (the almost ubiquitous zircon, magnetite and ilmenite being represented by less than a dozen grains) that no definite conclusion could be drawn from a negative result with regard to the presumably rarer accessories. In the notes below, other accessories are only mentioned in cases in which they seemed to offer special interest.

Kaolins.

Limoges, France.—Residue very small, containing a few minute milky-white octahedra of xenotime, transparent and glassy at the edges, associated

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with rare elongated and short stout prisms of zircon. More abundant are irregular amorphous pinkish granules which, as they often enclose crystals of xenotime and give micro-chemical reactions for phosphoric acid, and apparently also for yttria, are presumed to be alteration products of that mineral. The other elements of the residue are tourmaline in minute slender, white, blue and brown needles, magnetite in minute splendent octahedra and aggregates, ilmenite showing a yellowish alteration product, anatase in irregular bluish white grains, and pseudobrookite represented by a single transparent tabular crystal of deep red colour.

Carlsbad, Bohemia.—Rare grains of unmistakable monazite and anatase, mingled with abundant splendent prisms of zircon and rare octahedral crystals which, from the form and optical characters, so far as they can be determined, might be either zircon or xenotime. A single rather ill-formed specimen appears to be one of the characteristic intergrowths of the two minerals, and in this case the said octahedra, and a number of discoloured grains that could not be satisfactorily determined, may be presumed to be xenotime. A peculiar feature of this kaolin is a great abundance of siderite in rounded aggregates, evidently of secondary origin, ranging from microscopic grains up to the size of a pea, or larger.

These two kaolins appear to result from the decomposition of pegmatites or of muscovite-granites. Washings were also made of kaolin from Seilitz, near Meissen, Saxony (syenite ?), Schemnitz, Hungary (trachyte ?), and Türkismühle, Nahe, Rhenish Prussia. The residue of the second was comparatively abundant, but relatively small in the other two. Zircon occurs in all in sharp angled splendent prisms, with which rounded forms rich in faces are associated in the Schemnitz rock. The secondary titanium minerals are anatase in the first (possibly after original titanite, as the ilmenite grains show little or no alteration), rutile (sagenite) in the second, and a yellowish aggregate (leucoxene ?) in the third. Dirty white opaque grains in the Schemnitz rock are possibly altered titanite.

Pegmatites.

Hitterö, Norway.—Residue extremely small, with rare grains of zircon and a single grain of titanite.

Ronsperg, Bohemia.—Residue small, mainly composed of garnet with rare tourmalines, zircons and monazite. The specimen, like the preceding, is a typical graphic granite.

Davos, Switzerland.—Residue of garnet with extremely rare zircons.

Offenbanya, Hungary.—Residue consisting mainly of coarse tourmalines and garnets; zircon and iron minerals extremely rare.

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Glaser-Haj, Hungary.—Garnet only, no zircon or iron minerals observed.

Chaum, Pyrenees.—Tourmaline only, no zircon observed.

Vallée de Burbe, Pyrenees.—A single grain of zircon only, represents the rare accessories.

Geyer, Saxony.—Residue small, consisting mainly of prismatic zircons with rare octahedral forms that may be either zircon or xenotime, a single fragment of monazite.

Selb, Bohemia.—Residue, apart from tourmaline and epidote, extremely small, consisting mainly of iron minerals and rare grains of zircon and orthite (?).

Pisek, Bohemia.—Residue abundant, but consisting almost exclusively of fragments of the macroscopic monazite and xenotime for which the locality is celebrated, perfect microscopic crystals being extremely rare.

Striegau, Silesia.—Residue consisting of fine white epidote and beautiful microscopic tourmalines, the heavy accessories being rather rare, small, ill-formed and discoloured by iron oxide, so that their determination is somewhat difficult. Zircon and xenotime occur, but no monazite was observed. Anatase and orthite are rare.

Fuchsberg, Striegau, Silesia.—Abundant residue of coarse tourmaline, apatite, and fine green epidote. Zircon abundant in rather large splendent prisms, with which are associated rare octahedral forms which have more the aspect of zircon than of xenotime.

Oberbessenbach, Spessart.—Residue mainly of magnetite and garnet, with a few large zoned white and yellow zircons and numerous fragments that may be of macroscopic yellow zircons or of monazite. Rather large opaque and rudely formed octahedra occur that are probably partially altered xenotimes, a conclusion that is favoured by one or two ill-formed grains that appear to be intergrowths of xenotime and zircon.

Glattbach, Spessart.—A great quantity of garnet (spessartine) of remarkable beauty and perfection of form, numerous and comparatively large intergrowths of xenotime and zircon, with rarer isolated individuals of the same minerals and of monazite.

Aplites.

Grotto Doccei, Elba.—Numerous but minute intergrowths of xenotime and zircon, whitened, but of singular beauty and perfection of form, with rarer isolated grains of the same minerals, monazite and orthite with strong pleochroism suggestive of andalusite.

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Stutzerbach, Thuringia.—Zircon rare and ill-formed, but rather large, magnetite in fine octahedra.

Beresovsk, Ural (*Beresite*).—A great quantity of cubic pyrites with rare magnetite, zircon, monazite and titanite, the latter possibly of secondary origin, as it is whitish, and in other respects different in aspect from the original titanites of the other rocks examined.

Muscovite Granites.

Heidelberg, Baden.—Residue mainly composed of tourmaline and handsome garnets like those of the pegmatite of Glattbach. The heavy residue is very small, and composed of small and mainly rounded grains that, being discoloured by oxide of iron, are not easily determinable. Unmistakable grains of zircon and monazite were observed, and xenotime is probably also present, as indicated by rare octahedra. These might be zircons, but are more probably xenotime, as a couple of ill-formed grains that are almost certainly intergrowths of the two minerals were observed.

Eibenstock, Saxony.—Zircon abundant and fine, rutile also abundant and with the aspect of cassiterite, but giving the titanium reaction with the blowpipe; monazite, xenotime and anatase rare. The grains referred to xenotime are dirty and ill-formed, but the occurrence of the mineral is apparently confirmed by a few cases of intergrowth, though these are not so perfect as might be desired for a perfectly satisfactory identification.

Selb, Bavaria.—Zircon abundant, mostly semi-opaque, whitened and pitted (malaconised). The comparatively rare grains referred to xenotime have suffered the same alteration, and are therefore scarcely distinguishable. Apparent intergrowths of the two occur rarely. The rather rare monazite, on the contrary, is unaltered, bright yellow, often coated with oxide of iron.

Asch, Bohemia.—An almost completely decomposed rock, which has perhaps furnished the kaolin from the same locality, as the heavy residue is similar, being composed almost exclusively of zircon and anatase.

Königshain, Silesia.—Fine zircons with a great abundance of beautifully crystallised brown epidote.

Severn, Vosges.—Residue, exclusive of tourmaline, small, consisting of extremely pellucid zircons and greenish anatase.

Berzet, Auvergne, France.—Zircon abundant and fine, mostly rounded, though sharp angled forms also occur; monazite comparatively rare in

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rounded grains, rarely with distinct faces; blue anatase abundant, fine in colour, but ill formed.

Porto, Portugal.—Zircon with much yellow and brown anatase, rarely in perfect crystals, rare grains of brookite and of a black mineral with a yellow margin like that of the two-mica granite from the same locality.

Muscovite-Biotite Granites.

Wunsiedel, Bavaria.—Zircon abundant in extremely handsome elongated prisms, often rounded at the edges and irregularly pitted, as if they had suffered an action of re-absorption; the rare octahedral grains have more the aspect of zircon than of xenotime; blue and green anatase, brookite, apatite and andalusite.

Frauenthal, Bohemia.—Residue, consisting mainly of tourmaline and andalusite, with rare zircons and fine crystals of blue and green anatase.

Reuth, near Gefrees, Fichtelgebirge.—Much apatite with zircon, monazite and xenotime. The two last not being well defined in form and colour from zircon, were verified with the spectroscope. Intergrowths of xenotime and zircon occur, but are ill defined, owing to the almost complete envelopment of the central crystal of zircon by the xenotime.

Johanngeorgenstadt, Saxony.—Zircon abundant in large, handsome prisms and small rounded grains; yellow rutile also abundant; monazite comparatively rare.

Corwan, Cornwall.—Zircon abundant in small and handsome prisms, with extremely elongated pyramids; iron-stained and ill formed grains may represent monazite or xenotime, or both, but are perhaps zircons.

Haytor, Devonshire.—Zircon and monazite tolerably abundant in pellucid grains, mostly rounded at the edges and angles.

Louchon, Pyrenees.—Zircon abundant in elongated prisms and rounded forms, rich in faces, rare grains of rutile.

Altweiler, Vosges.—Much zircon and blue anatase; a black mineral of which a single grain shows faces apparently of the tetragonal system, could not be determined.

Bressoir, Vosges.—Apatite abundant with fine blue anatase; zircon and andalusite rare.

Porto, Portugal.—Zircon, anatase and very handsome brookite are comparatively rare; more abundant is an opaque yellowish mineral, which evidently results from the alteration of a black one, as grains with a black centre and a yellow semi-transparent border are frequent. The appearance is that of ilmenite with a superficial alteration to leucoxene, or of

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pyrites altered to limonite, but negative results were obtained in tests for titanium, and with acids. The form is apparently tetragonal, as several tolerably well formed prisms and a single perfect octahedron were observed. A test for silica with hydrofluoric acid gave a negative result. The same mineral occurs rarely, and not so well defined in form, in the muscovite granite of the same locality.

Biotite Granites.

As most of the representatives of this group at hand were known to carry titanite, and were therefore presumed to be unfavourable for the special purpose of this investigation, only a few were examined on account of some peculiarity of the type or of interest in the locality.

Jekaterinenburg, Ural (*Plietengranite*).—Great abundance of large and extremely handsome titanite, few and small zircons, green epidote, much magnetite, apatite abundant.

Wiborg, Finland (*Rapakiwi*).—Comparatively large and handsome zircons, with apatite. The larger zircons often contain crystalline inclusions which in part seem to be small needles of the same mineral, in part apatite.

Breitenstock, Switzerland (*Protogine Granite*).—Great abundance of small but very fine zircons, with fragments of tourmaline.

Heidelberg, Baden (*Porphyritic Granite*).—Zircon and apatite abundant, the former frequently enclosing crystals of magnetite.

Serra de Conillas, Portugal.—Zircon and apatite, the latter much the most abundant, large and fine, often with pleochroic bands of dust-like inclusions arranged parallel to the prismatic faces.

Shap, Westmoreland.—Zircon, apatite and titanite abundant and fine, pyrites very rich in faces.

Granite-Gneiss.

Altweiler, Vosges.—Residue small, consisting principally of apatite with rare zircons.

Repistye, Hungary.—Fine zircons with tourmaline and rare grains of anatase.

Streitkopf, Thuringia.—Residue abundant, with apatite and zircon in about equal proportions.

Ruhla, Thuringia.—Handsome sharp angled zircons abundant, with fine crystals of apatite and with titanite.

Trusethal, Thuringia.—Zircon extremely abundant and exceptionally fine, full of cavities, and the larger ones with included crystals which appear to be small zircons.

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Albersweiler, Bohemia.—Residue small, with more apatite than zircon.

Fussberg, near Aschaffenburg, Spessart.—Zircon extremely abundant in small and for the most part rounded grains. No other rare accessories observed.

Granberg, Spessart.—Zircon abundant with beautiful zonal structure, apatite abundant, monazite rather rare but in large grains, rutile (?) rare, no xenotime seen.

Ruhwald, near Gailbach, Spessart.—Much magnetite; non-magnetic residue very dirty and discoloured by oxide of iron, with zircon, monazite, and xenotime in about equal proportions; apatite, which is given by Ritter, extremely rare, only two grains being found in two preparations.

Lochmühle, near Rochlitz, Saxony.—Of the two specimens from this place, one is decidedly gneissic, the other decidedly granitic in aspect. Both are rich in biotite, and from their general appearance were, before washing, judged to be unfavourable for the main purpose of this investigation. Both gave extremely abundant heavy residues, in which small milky-white octahedra of xenotime predominate. The grains are often transparent and glassy at the margins, the troubled milky appearance of the central portions being apparently due to fracturing, rather than to alteration. Monazite in tabular rounded crystals, rich in inclusions, is abundant in the granitic type, but lacking in the other. The same type has rare prisms of apatite with a dark centre, full of dust-like inclusions and larger rounded masses that resemble glass inclusions. Both rocks have an abundance of colourless zircons, rich in inclusions of prismatic and pyramidal types, the latter often compressed giving very singular and beautiful rhombic, rarely trigonal, tabular forms. Rare grains of anatase in both rocks. If xenotime should, like monazite, become commercially valuable, these rocks or the detritus from them might repay examination.

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On Blödite from the Punjab Salt Range.

By F. R. Mallet, late Superintendent, Geological Survey of India.

[Read June 17th, 1897.]

THE Salt Range of the Northern Punjab derives its name from the numerous beds of rock salt which are there included amidst the pre-Cambrian strata. Some of these salt beds are of great purity and immense thickness, and have been utilised as a source of the mineral from a remote period, while extensive mines have been opened out by Government since the annexation of the province. The blödite referred to below was discovered in these workings by Dr. H. Warth, lately Deputy Superintendent of the Geological Survey of India, but who, at the time alluded to, held charge of the mines in question.

It appears, from information for which I am indebted to Dr. Warth, that the blödite was first discovered about the year 1875, in the Mayo mines at Khewra, a few miles north of Pind Dádun Khán. It occurred in crystals about half-an-inch long, which, together with colourless and transparent cubic crystals of salt, formed a drusy coating on the sides of a narrow fissure in the rock salt. It was not accompanied by any other mineral of secondary origin; except the salt crystals just mentioned. Although glauberite and selenite have been found under similar circumstances in the same mines, they were not in association with the blödite. About 1887, bigger crystals of the latter, some of which were as much as 3 or 4 inches long and nearly as broad, were discovered in the Varcha mine, which is situated 65 miles W.S.W. from those mentioned above. The mineral from both localities was in very perfect crystals, the majority of them possessing smooth, or even lustrous faces, and sharply-cut edges and angles.

Some of the crystals from the Mayo mines were given by Dr. Warth to Professor Quenstedt, who described their crystallographic character in his *Handbuch der Mineralogie*.[1] The similarity of the crystals to those of the same mineral from Stassfurt is pointed out; but the complication is introduced of choosing axes different from those previously adopted by Brezina, Groth and Hintze, and vom Rath, for the Hallstadt and

[1] 3rd edition (1877), p. 645.

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Stassfurt blödite, and of orientating the crystal in a different way. What these writers regard as the front of the crystal, in the normal position, Quenstedt places behind. The symbols for 11 or 12 forms are given, all of which are amongst those previously observed on the Stassfurt mineral.

About the same time the blödite from the Mayo mines was examined in respect to its crystallography by Professor Schimper.[1] Adopting the same axes as Groth[2] and vom Rath[3], Schimper observed 13 forms which are common to the Stassfurt crystals, and which include all those recorded by Quenstedt. He likewise determined two new forms, not hitherto noticed on the Stassfurt blödite; and pointed out the similarity in habit of the mineral from the two localities, as well as the agreement in value of corresponding angles, Schimper's measurements generally differing from Groth and Hintze's by not more than one minute.

Dr. Warth has recently given me the opportunity of examining 11 specimens from Varcha, and I have also received some out of the same mine from Mr. Holland, of the Indian Geological Survey. Besides most of those mentioned by Schimper, I noticed three forms on one or other of the crystals, which are new in respect to the Salt Range mineral, but have been described by the authors quoted as occurring on the Stassfurt blödite; this makes a total of 18 forms as given below.

c	$=(001)=0P$	Common to Stassfurt and Salt Range. W. Schimper.
d	$=(011)=P\infty$	
p	$=(111)=-P$	
m	$=(110)=\infty P$	
n	$=(210)=\infty P2$	
a	$=(100)=\infty P\infty$	
b	$=(010)=\infty P\infty$	
λ	$=(310)=\infty P3$	
ν	$=(120)=\infty P2$	
q	$=(\bar{2}01)=+2P\infty$	
u^4	$=(\bar{1}11)=+P$	
s	$=(\bar{2}11)=+2P2$	
o	$=(\bar{1}21)=-2P2$	

[1] *Zeitsch. f. Kryst. u. Min.*, I. (1877), 70.
[2] *Zeitsch. d. deuts. geol. Gesell.*, XXIII. (1871), 670.
[3] *Pogg. Annalen*, CXLIV. (1872), 586.
[4] y in original.

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x	$=(\bar{1}21)=+2\breve{P}2$	Common to Stassfurt and Salt Range.
y	$=(\bar{2}21)=+2P$	
e	$=(021)=2\breve{P}\infty$	F. R. MALLET.
μ	$=(130)=\infty\breve{P}3$	Salt Range only.
f	$=(\bar{1}44)=+\breve{P}4$	W. SCHIMPER.

Of these forms, p, c, d, m, n are predominant (as they are in the Stassfurt crystals also). None of them are absent, or even subordinate, in any fairly perfect crystals that I have examined. o and q are sometimes of fair size, while the rest are generally small and often quite minute. Some are of very rare occurrence; although a and b are mentioned by both Quenstedt and Schimper, I have never noticed the latter, and the former only once. f was also absent on the Varcha crystals, and λ appeared on but one.

The authors quoted observed 21 forms on the Stassfurt crystals, of which five have not been noticed on those from India. But probably this number would be reduced if still further specimens were submitted to examination.

The mineral is colourless, and to a large extent transparent; but there are few crystals in which the limpidity is not here and there imperfect. The examination of sections under the microscope shows that this cloudiness is due to multitudinous cavities, which generally vary in size from 0·1 or 0·2 millimetres downwards. Some are very irregular in outline, but the larger proportion are less markedly so, and often rudely elliptical. Many look more or less like negative crystal cavities, and some with distinct polyhedral boundaries undoubtedly are such. In rare cases one or two of the predominant forms like (001),0P and (111),−P can be recognised. With few exceptions the cavities are nearly filled by a colourless liquid, the accompanying bubbles being comparatively minute; but in a small minority no bubble is apparent, or again, there is no liquid. In some exceptionally large cavities, about a millimetre long, the movement of the bubbles can easily be seen when the specimen is turned. A few cavities were noticed containing colourless crystals in the liquid: the outline of the only one with very determinate form was rectangular, and nearly square, suggestive of sodium chloride.

An optical examination of the mineral gave results in fairly close agreement with those obtained by Groth and Hintze in respect to that from Stassfurt.[1] The crystals are negative, with the optic axes in the

[1] *l, c.*

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plane of symmetry, the bisectrix $\mathfrak{a}$ nearly bisecting the acute angle between the vertical and clino-diagonal crystallographic axes. With sections parallel to the plane of symmetry, and bounded on one side by the trace of the basal plane, the mean of numerous determinations of the angle $\mathfrak{a} \wedge \dot{c}$ (= angle β − angle between trace of basal plane and $\mathfrak{a}$) was :—

For red light[1]	...	42°9′
For blue light[2]	...	41 5

The values obtained by the authors quoted, using similar light, were 44°48′ and 43°21′.

With sections perpendicular to the bisectrices, the following mean results were obtained :—

		$2H_a$.	$2H_o$.
For red light	...	71°22′	111°51′
For blue light	...	73 26	109 0

The value of $2V_a$ derived from these is 70°18′ for red, and 72°36′ for blue ; Groth and Hintze's angles are 70°5′ and 72°34′. When a section perpendicular to $\mathfrak{a}$ is examined by white light, the inclined dispersion is very clearly displayed in the colouration of the rings and brushes.

The sections employed not having been cut, nor the observations made, with the precision now attainable by means of the instruments devised by Mr. A. E. Tutton, the above results cannot be regarded as more than fairly good approximations. In the one or two cases where my results differ from Groth and Hintze's by only a few minutes, such close agreement is little more than fortuitous.

In some of the earlier accounts the blödite from more than one European locality is described as efflorescent,[3] while two or three writers allude to the substance attracting moisture.[4] The Indian crystals are, however, perfectly stable in the air (of London). Some which I have had in my possession for the last eight years, without protection from the atmosphere, show no sign of alteration; and further, a sample taken for

[1] Red glass. [2] Ammoniacal cupric sulphate.

[3] *John*; *Chemische Schriften*, VI. (1821), 240 (as quoted by Tschermak : I have been unable to refer to the original). *Göbel*; *G. Rose, Reise nach dem Ural* (1842), II. 270. *Tschermak*: *Sitzungsb. d. k. Akad. der Wiss. Wien*, LX. 1 *Abth.* (1869), 722. Also *v. Foullon*; *Jahrb. k. k. geol. Reichanst. Wien*, XXXVIII. (1888), 3. Tschermak, however, found the Hallstadt mineral perfectly stable.

[4] *Hayes*; *Proc. Nat. Hist. Soc. Boston*, V. 391. *Groth and Hintze*; *l.c.*; *v. Foullon*; *l.c.*

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analysis, after being finely powdered and placed in a desiccator with oil of vitriol till the weight remained constant, only lost ·07 per cent., which was, no doubt, partly due to the liquid in the cavities. Another portion, again, exposed in fine powder to the air for a week during weather of medium humidity, only gained ·08 per cent.

The mineral, freed from moisture as mentioned above, yielded on analysis—

		I.	II.	Mean.[1]	Theory.[1]
MgO	...	11·96	11·97	11·97	12·04
Na_2O	...	18·48	18·59	18·53	18·56
SO_3	...	47·75	47·89	47·82	47·86
H_2O	...	21·59	21·50	21·54	21·54
NaCl	...	·07	·07	·07	
		99·85	100·02	99·93	100·00

There was likewise an unweighable trace of material insoluble in water, and the same of lime. The chlorine is doubtless in combination with sodium. As previously mentioned, the blödite was found on rock salt, and crystals of salt are associated with it, and sometimes embedded in it; hence care is necessary in obtaining a sample as free from chlorine as the above. The minute quantity found is probably due, in part at least, to the saline matter dissolved in the liquid of the cavities.

Some of the earlier accounts differ as to the tenacity with which the water in blödite is retained on heating the mineral. According to John the massive blödite of Ischl loses the whole of its water when heated for two hours in a water bath.[2] Tschermak, on treating the Hallstadt mineral in the same way until the weight remained constant, found that three-eighths of the water was expelled, the remainder being given off on ignition; he consequently wrote the formula of the mineral (which he named simonyite) $2MgSO_4 2Na_2SO_4.5H_2O.3aq$.[3] Groth and Hintze, on the other hand, found that Stassfurt blödite loses about 8·8 per cent. at 100° C. and 10·12 per cent. at 150°, the former figures being, as they point out, in excess of three-eighths (8·08 per cent.) of the total water.[4] These

[1] The atomic weights used are those adopted by Prof. F. W. Clarke in his *Recalculation of the Atomic Weights*. New Edition, 1897.

[2] *l. c.*

[3] *l. c.* and *Jahrb. k. k. geol. Reichsanst.* XXII. (1872), *Min. Mitth.* 58.

[4] *loc. cit.*

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results are in agreement with those obtained by vom Rath[1] on heating the mineral from the same locality, which are as follows:—

Loss on heating up to 130°	10·05 per cent.
Further loss on heating up to 300°[2] ...	10·09 ,,
,, ,, till the salt melted	1·16 ,,
Total loss	21·30

The loss at 130°, as he remarked, is nearly half the total, and he consequently adopted the formula $MgSO_4.Na_2SO_4.2H_2O+2aq$.

In respect to the Salt Range mineral, it was found that decomposition by loss of water commenced at about 85° C.; but, at even considerably higher temperatures, very protracted heating was necessary before the weight remained constant:—

Duration of heating.	Temp.	Loss per cent.	Total loss per cent.
39 hours	100° C.	9·44 (weight constant)	9·44
62 ,, more	110°	·37 (ditto)	9·81
114 ,, ,,	120°	·95 (ditto)	10·76

Thus at 120° exactly two molecules of water were driven off, and no further loss of weight took place on continued heating at the same temperature. But a very slight increase of temperature was sufficient to induce still further loss. After 16 hours at 125° this amounted to ·07 per cent., and after 27 hours longer at increasing temperatures up to 150°, to 1·05 per cent. more (total 11·88), these experiments not being continued till the weight was constant. When the mineral was heated at once to 150° 10·32 per cent. was expelled in 4 hours, but 12 hours more were required to raise the loss to 10·78, and the substance continued to lose water slowly when the heating was carried on still longer.

The Salt Range blödite, therefore, like the Stassfurt, loses two molecules of water more easily than the other two. The first were expelled between 85° and 120°, while the remainder began to go off at about 125°.

As long ago as 1842, Rose expressed the opinion that the blödite of certain salt lakes near Astrakhan was formed through the mutual decomposition of Epsom salt and common salt, whereby sodium sulphate and magnesium chloride result, the former uniting with the undecomposed Epsom salt.[3] Tschermak originally thought that the Hallstadt blödite

[1] *loc. cit.*

[2] Or 200? The original is not clear.

[3] *l. c*

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was due to the alteration of polyhalite; but later on he suggested that it was derived from kieserite.[1] Comparatively recently van't Hoff and van Deventer, incidentally to a research on transformation temperature in relation to chemical change, refer to two methods by which blödite may be formed artificially: firstly, by the combination of sodium sulphate with magnesium sulphate, and secondly, which is of more interest at present, by the double decomposition of magnesium sulphate and sodium chloride, according to the following equation:—

$$2SO_4Mg.7H_2O + 2NaCl = (SO_4)_2MgNa_2.4H_2O + MgCl_2.6H_2O + 4H_2O.$$

The transformation temperature with the salts in the above proportions is 31°C. Below this point the reaction from right to left occurs, but above it the reverse chemical change takes place, and blödite is formed together with magnesium chloride. The transformation temperature may, however, apparently be greatly lowered by the presence of common salt in excess, with which is probably connected "the technical prescription which forbids the transgression of a temperature of 5°, during the working of brine containing common salt and magnesium sulphate for glauber salt; as above that temperature, according to the preceding experience, astrakanite (blödite) instead of glauber salt might separate out."[2]

In 1873, a lenticular band of mixed sylvine and kieserite was discovered by Dr. Warth in one of the beds of "*kallar*," or impure rock salt, of the Mayo mines. In a moist atmosphere the kieserite becomes disintegrated on the surface, and exhibits a constantly deciduous coating owing to its changing into epsomite.[3] As the latter mineral "impregnates the *kallar* and thin layers between the salt beds, and also effloresces from the surfaces of the red marl in old workings,"[4] it may perhaps be inferred that, although but one actual band of kieserite has been discovered, the mineral is still somewhat widely, if sparingly, distributed, in a scattered way, through the saline strata; and there scarcely seems much room for doubting that the blödite has been formed by the solution and interaction of rock salt and the magnesian minerals just alluded to.

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[1] *l. c. & Sitzungsb. d. k. Akad. Wiss. Wien.* LXIII. 1 *Abth.* (1871), 321.

[2] *Zeit. f. physikalische Chemie*, I. (1887), 176.

[3] *Jahrb. d. k. k. geol. Reichanst*, XXIII, 2 *Abth.*, 136; *and Records, Geol. Surv. India*, VII, 64; *Memoirs, Geol. Surv. India*, XIV, 80.

[4] *Wynne, Memoirs, l. c.* 79.

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On a new occurrence of Apophyllite in South Africa.

By J. A. Leo Henderson, M.E.

(Communicated by Prof. J. W. Judd, C.B., F.R.S.)

[Read April 6th, 1897.]

IN the so-called "blue ground" of the farm Koppiesfontein, in the neighbourhood of Jagersfontein, Orange Free State, a prospecting shaft was put down; and in the 110 ft. level struck a blue-grey, soft, and apparently talcose serpentine-like mass. The latter was densely studded with a great number of small, completely formed, light coloured crystals, which in some places lie very close together. The crystals may be easily isolated from this matrix, in which they leave smooth-sided and sharp-edged moulds. The isolated crystals are nearly colourless, or feebly yellowish, and strongly translucent; attain a maximum size of about $\frac{5}{16}$th inch (0·8 cm.), and are seldom smaller than $\frac{3}{16}$th inch (0·5 cm.), being therefore of almost uniform dimensions. At first sight one would be inclined to consider the eight-sided bi-pyramidal crystals as regular octahedra; however, apart from an inequality of the edges, one notes immediately, even in those individuals which are still imbedded in the hand-specimen, a perfect monotome cleavage cutting off two of the diametrically opposite four-edged solid angles, and forming very perfect smooth cleavage planes with brilliant pearly lustre. This behaviour first gave rise to the conjecture that the above-mentioned crystals were apophyllite. This, however, seemed to be contradicted by the fact that apophyllite generally occurs in crystals encrusting the matrix, whilst in this case the completely formed crystals are imbedded in the mother-rock. However, further mineralogical, physical and chemical investigations have proved that the mineral in question is beyond doubt apophyllite, which therefore occurs in this deposit under very unusual conditions.

Various difficulties presented themselves in the measurement of the crystal angles; such as the presence of hardly-separable particles of the surrounding matrix on the faces of the isolated crystals, which rendered a perfect reflection impossible; further, the surfaces themselves were rough,

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and in parts not quite regularly formed. Accordingly the measurements had to be executed with the aid of thin glass plates, fastened on to the surfaces. Even if the measurements may only be regarded as approximate (the extreme values gave differences up to $1\frac{1}{2}^{\circ}$), it was nevertheless found, from a large number of determinations, that the crystals, composed of eight triangular faces, possess only two kinds of edges, eight of which gave an angle of about 105°, the other four an angle of about 120°. The former value would correspond to the polar edge angle, the latter to the middle edge angle, of the proto-pyramid $P\{111\}$ of apophyllite. No forms other than the proto-pyramid P were observed on any of the many individuals examined. Often two individuals are found interpenetrating being apparently twinned on the same plan as that observed by Schrauf on the apophyllite crystals from Greenland, in which the axis of twinning is the normal to $P\{111\}$, a face of a more obtuse pyramid representing the plane of composition.

The specific gravity of the crystals, determined in Thoulet's solution by means of Westphal's balance, was found to be 2·371; thus agreeing with that of apophyllite. The hardness, again, is 4 to 4·5. The excellent basal cleavage, with its characteristic pearly lustre, has already been mentioned above. These thin basal cleavage plates are excellently adapted for examination in polarised light. As it is not necessary for the object of this communication to enter upon a detailed description of the optical phenomena, or even to compare the latter specially with the optical behaviour of the mineral from other localities lately investigated so exhaustively by C. Klein, it will be sufficient here to discuss only those phenomena which prove that the optical behaviour of the South African crystals lies within the limits of the phenomena already observed in apophyllite. Basal cleavage lamellæ of square form, examined under the microscope, reveal a colourless substance traversed by two dull grey lines which cross the crystals diagonally. These fine lines, visible even to the naked eye, seem to be composed of included substance from the surrounding matrix. As they correspond to the horizontal axes, a, in the basal plane, they divide the square lamella into four equal triangular quadrants. The small breadth of this layer of impurities imbedded in the plane of the axes, a, c, appears to be uniform in all the various lamellæ taken from the same crystal in different heights. In parallel polarised light, between crossed nicols, no position of the object gives total darkness. An isotropic square central field, as has sometimes been observed, does not present itself in any part of the crystals. In each of the four quadrants, thin polarising systems of bands appear on a dark ground, and lie more or less perpendicular to

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the respective sides of the tetragonal sections, running together in the centre, at the point of intersection of the grey lines.

In convergent polarised light the interference figures in each of the four quadrants may be examined separately. They prove to be biaxial, with a very small optic angle, but still with a distinct separation of the hyperbolic brushes; the optic axial plane appears to be parallel to the corresponding side of the square section, so that in the two opposite quadrants the axial planes are parallel, while in two contiguous quadrants they are at right angles to each other. The lamellæ taken from different heights of the crystal proved themselves conformable to each other in every respect. The interference figure, with its approximately black and white rings, resembles in character that of leucocyclite.

The mineral fuses easily before the blowpipe; a splinter imparts the violet potassium colour to the flame. Heated in a closed tube, the mass exfoliates, gives off water in considerable quantity, and becomes opaque. The powdered mineral, moistened with water, gives a strong alkaline reaction with litmus, as well as with turmeric paper. Hydrochloric acid decomposes the powder with separation of slimy silica. The solution gives, with chloride of platinum, the microchemical reaction for potassium. In all these points it shows a behaviour completely identical with that of apophyllite.

An analysis of these crystals, made by Dr. Röhrig, of Leipzig, gave the following composition :—

SiO_2 ..	...	...	= 51·16
$Al_2O_3+Fe_2O_3$	...	...	= 1·60
CaO ...	...	...	= 25·44
MgO ...	...	...	= 0·29
K_2O ...	...	...	= 3·35
Na_2O ...	...	...	= 0·43
H_2O ...	...	...	= 16·73
F ...	...	...	= 1·04
NH_3 ...	...	...	= 0·11
			100·15

This analysis proves the mineral to be undoubtedly apophyllite, since it agrees very closely with the best analyses of this mineral. With regard to the amount of fluorine, in accordance with the results of Ch. Friedel (*Zeitschrift für Krystallographie* XXVI. 1896, p. 221), it was found that this apophyllite also does not give any fluorine by treatment with

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sulphuric acid, but that if the mineral be treated with dilute hydrochloric acid, according to his method, and the filtrate precipitated with ammonia, a precipitate containing Ca, Si, and F is formed, from which SiF_4 can be obtained. On a plate of glass the name and locality of the mineral could be etched. The ammonia was driven off by decomposing the fine powder with dilute sulphuric acid, and by afterwards boiling with an excess of soda.

This occurrence of apophyllite is remarkable, on the one hand, because the crystalline form is solely confined to the development of P{111}; and on the other, because it occurs in an imbedded condition, instead of incrusting the matrix, as is more usually the case. Only two occurrences of imbedded apophyllite are, it appears, mentioned in the literature, namely, the "lenticular, more or less radially foliated," apophyllite described by J. Rumpf as imbedded in thin coaly strata, which lie in a decomposed basaltic tufa, near the church of S. Pietro, close to Montecchio-Maggiore (*Tscherm. Min. Mitth.* II. 1880, p. 388), and the xylochlore of Sartorius von Waltershausen (apophyllite, according to Kenngott), which was found in pyramidal crystals in a fossil tree trunk in the volcanic tufas of Halbjarnastadr Kambur, in N. Iceland (*Vulcan. Gesteine von Sicilien und Island*, 1853, p. 298). The nature of the surrounding matrix is, however, in South Africa quite different from that of the last-mentioned occurrences.

It is difficult to determine, from the scanty material at disposal, how far this matrix of the crystals, called "blue ground" at the place of discovery, corresponds with the well-known and much-discussed diamond-iferous "blue ground" of Kimberley. In favour of the similarity of the two deposits is the fact that from the "blue ground" of Koppies-fontein under discussion red garnets, particles of titanic iron ore and smaragdite were washed, which latter are characteristic of the Kimberley "blue ground." It is unknown to the author if the former is diamant-iferous; the "blue ground" of Jagersfontein is, as is well known, diamond bearing.

If the matrix of the crystals be finely pulverised, and placed in Thoulet's heavy solution, having a specific gravity of about 3, one observes in the scanty sediment a large number of sharp prismatic crystals of zircon, completely formed at both ends, and measuring up to 0·002″ (0·05 mm.) in length. An analysis of the Kimberley "blue-ground," by Flight gave I., whilst a not quite complete analysis of the apophyllite matrix yielded II.

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	SiO_2.	Al_2O_3.	Fe_2O_3.	FeO.	MgO.	CaO.	CO_2.	H_2O.
I.	39·73	2·31	—	9·69	24·42	10·16	6·57	7·55
II.	34—35	15·44	3·55	14·80	7·16	10—11	—	11·34

Although considerable differences, especially in the amount of alumina and magnesia, appear, and though it would be difficult to ascribe a serpentinous character to the matrix of the crystals in Koppiesfontein, yet a certain geological analogy between the two materials is not excluded as impossible. Finally, it may be mentioned, that in the "blue-ground" of Kimberley also zeolites, chiefly mesolite and natrolite, are found.

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A List of New Mineral Names.

By L. J. Spencer, M.A., F.G.S.

THE following is a list of recently published names, which are not to be found in the 6th edition (1892) of Dana's *System of Mineralogy*. Although it can scarcely be hoped to make such a list complete, it may still be useful for reference. Probably not more than a third of these are new minerals, which could, when completely determined, stand as distinct species.

Alexandrolite. S.M. Losanitsch, *Chem. News*, LXIX. 243, 1894; and *Ber. deutsch. chem. Ges.* XXVIII.(3), 2631, 1895.

A green, hydrated silicate of Al and Cr, resulting, with blue miloschine, from the decomposition of avalite. Servia.

Alexjejewite. A. Karnojitzky, *Zeits. Kryst. Min.* XXIV. 504, 1895 (V. Aleksyeev, *Verh. russ. min. Ges.* XXIX. 201, 1892). [This vol. p. 236.]

A wax-like hydrocarbon. Russia.

Andorite. J. A. Krenner, *Math. és term.-tud. Értesitö*, XI. 119, 1892. This vol. p. 286.

$2PbS.Ag_2S.3Sb_2S_3$. Rhombic. Hungary and Bolivia.

Ascharite. W. Feit, *Chemiker-Zeitung*, XV. 327, 1891.

$3Mg_2B_2O_5.2H_2O$. Ascherleben, Prussia.

Baddeleyite. L. Fletcher, *Nature*, XLVI. 620, 1892; XLVII. 283, 1892; *Min. Mag.* X. 148, 1893. E. Hussak, *Tsch. Min. Mitth.* XIV. 395, 1895. [This vol. p. 110.]

ZrO_2. Mono-symmetric. Ceylon and Brazil.

Bagotite. [T. Egleston, *Catalogue of Minerals*, (1887), 1889, p. 192; A. H. Chester, *Dictionary of the Names of Minerals*, 1896, p. 25; *Student's Index to the British Museum Collection of Minerals*, since 1885].

Green pebbles from Bagot, Ontario, have been in the British Museum since 1882; these are labelled bagotite, and are identified with the lintonite variety of thomsonite. Molybdenite comes from the same locality.

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Barium anorthite. See celsian.

Barium heulandite (heulandite baritica). D. Lovisato, *Rend. R. Accad. Lincei*, VI.(1), 260, 1897.

Heulandite with 2·55 per cent. BaO. Sardinia.

Basiliite. L. J. Igelström, *Geol. För. Förh.* XIV. 307, 1892; and *Zeits. Kryst. Min.* XXII. 470, 1894.

Hydrated antimonate of manganese. Sjö mine, Sweden.

Batavite. E. Weinschenk, *Zeits. Kryst. Min.* XXVIII. 157-160, 1897.

A scaly decomposition product, perhaps related to the micas or chlorites. Bavaria.

Bismutosmaltine. A. Frenzel, *Tsch. Min. Mitth.* XVI. 524, 1897.

$Co(As,Bi)_3$. Cubic. Schneeberg, Saxony.

Bixbyite. S. L. Penfield and H. W. Foote, *Amer. Journ. Sci.* IV. 105, 1897.

Ferrous manganite. $FeO.MnO_2$. Cubic. Utah.

Bliabergite. L. J. Igelström, *Zeits. Kryst. Min.* XXVII. 603, 1897; spelt bliabergsite in *Geol. För. Förh.* XVIII. 41, 1896. M. Weibull, *Geol. För. Förh.* XVIII. 515, 1896.

Shown by Weibull to be a brittle mica near ottrelite. Bliaberg, Sweden.

Blueite. S. H. Emmens, *Journ. Amer. Chem. Soc.* XIV. 207, 1892; S. L. Penfield, *Amer. Journ. Sci.* XLV. 496, 1893.

Shown by Penfield to be nickeliferous pyrites. Sudbury, Canada.

Bouglisite. E. Cumenge [A. Lacroix, *Bull. Mus. d'Hist. Nat. Paris*, 1895, p. 42]. F. A. Genth, *Amer. Journ. Sci.* XLV. 32, 1893.

Described by Genth as a mixture of anglesite and gypsum. $2PbSO_4+CaSO_4+2H_2O$. Boleo, Lower California.

Brazilite. E. Hussak, *Neues Jahrb. Min.* II. 141, 1892; *Min. Mag.* X. 158; XI. 110.

Synonym of baddeleyite.

Burmite. F. Noetling, *Records Geol. Survey India*, XXVI. 31, 1893. O. Helm, *Ibid.* XXV. 180, 1892; XXVI. 61, 1893; and *Schriften Ges. Danzig*, VIII. 63, 1894.

An amber-like resin from Upper Burma.

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Canfieldite. S. L. Penfield, *Amer. Journ. Sci.* XLVII. 451, 1894; XLVI. 107, 1893. [*Min. Mag.* X. 336; XI. 40.]

$4Ag_2S.(Sn,Ge)S_2$. Cubic. Bolivia.

Caswellite. A. H. Chester, *Trans. N.Y. Acad. Sci.* XIII. 181, 1894. [This vol. p. 243.]

An altered biotite, allied to clintonite. New Jersey.

Celsian. H. Sjögren, *Geol. För. Förh.* XVII. 578, 1895.

Barium anorthite. $BaO.Al_2O_3.2SiO_2$. Anorthic. Sweden.

Chloroarsenian. L. J. Igelström, *Geol. För. Föhr.* XV. 471, 1893; and *Zeits. Kryst. Min.* XXII. 468, 1894.

Arsenate of manganese? Sjö mine, Sweden.

Chondrostibian. L. J. Igelström, *Geol. För. Föhr.* XV. 343, 1893; and *Zeits. Kryst. Min.* XXII. 43, 1893.

Hydrated antimonate of manganese and iron. Sjö mine, Sweden.

Clinozoisite. See klinozoisite.

Cosmochlore. See kosmochlor.

Crossite. C. Palache, *Bull. Dept. Geol. Univ. Calif.* I. 181, 1894. [This vol. p. 35].

A soda amphibole between riebeckite and glaucophane. California.

Cubaite. F. Vidal y Careta, *Crónica Científica, Barcelona*, XIII. 497, 1890; L. F. Navarro, *Anal. Soc. Esp. Hist. Nat.* XXI. *Actas*, p. 120, 1893.

A supposed cubic form of silica; shown by Navarro to be rhombohedra of quartz. See guanabaquite.

Cumengeite. E. Mallard, *Bull. Soc. fran. Min.* XVI. 184, 1893; E. Cumenge, *Compt. Rend.* CXVI. 898, 1893; A. Lacroix, *Bull. Mus. d'Hist. Nat. Paris*, 1895, p. 39. This vol. p. 164.

$PbCl_2.CuO.H_2O$. Tetragonal. Boleo, Lower California.

Cuprocassiterite. T. Ulke, *Trans. Amer. Inst. Mining Engineers*, XXI. 240, 1892; W. P. Headden, *Amer. Journ. Sci.* XLV. 108, 1893.

"$4SnO_2 + Cu_2Sn(OH)_6$." Shown by Headden to be a decomposition product of stannite. S. Dakota.

Cuprolodargyrite (Cupro-Jodargyrit). H. Schulze, *Chemiker-Zeitung*, XVI. 1952, 1892.

CuI.AgI. Chili.

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Derbylite. E. Hussak and G. T. Prior, *Min. Mag.* XI. 176, 1897; XI. 85, 1895.

$FeO.Sb_2O_5+5(FeO.TiO_2)$. Rhombic. Brazil.

Dicksbergite. L. J. Igelström, *Geol. För. Förh.* XVIII. 231, 1896.

Shown by M. Weibull and A. Upmark (*Ibid.* XVIII. 523, 1896) to be rutile. Dicksberg, Sweden.

Dietzeite. A. Osann, *Zeits. Kryst. Min.* XXIII. 588, 1894. To replace Dietze's name jodchromate (*Ibid.* XIX. 449, 1891).

$7Ca(IO_3)_2.8CaCrO_4$. Monosymmetric. Chili.

Dundasite. W. F. Petterd, *Catalogue of Minerals of Tasmania*, 1893, p. 26; and *Papers and Proc. Roy. Soc. Tasmania*, for 1893, 26, 1894.

"Hydrous carbono-phosphate of lead and alumina."

Elfstorpite. L. J. Igelström, *Geol. För. Förh.* XV. 472, 1893, and *Zeits. Kryst. Min.* XXII. 468, 1894.

Hydrated arsenate of manganese? "Rhombic." Sjö mine, Sweden.

Elpidite. G. Lindström, *Geol. För. Förh.* XVI. 330, 1894; G. Nordenskiöld, *Ibid.* p. 343.

$Na_2O.ZrO_2.6SiO_2.3H_2O$. Rhombic. Greenland.

Epididymite. G. Flink, *Geol. För. Förh.* XV. 201, 1893; and *Zeits. Kryst. Min.* XXIII. 353, 1894. [This vol. p. 100.]

$BeNaHSi_3O_8$. Rhombic. Greenland.

Fluor-adelite. See tilasite.

Folgerite. S. H. Emmens, *Journ. Amer. Chem. Soc* XIV. 205, 1892; S. L. Penfield, *Amer. Jour. Sci.* XLV. 491, 1893.

Shown by Penfield to be identical with pentlandite. Sudbury, Canada.

Franckeite. A. W. Stelzner, *Neues. Jahrb. Min.* II. 114, 1893.

$5PbS.2SnS_2.Sb_2S_3$. Bolivia.

Fuggerite. E. Weinschenk, *Zeits. Kryst. Min.* XXVII. 577, 1897.

Tetragonal? Between åkermanite and gehlenite in composition, but dimorphous with this group. Tyrol.

Geikielite. A. B. Dick, *Min. Mag.* X. 145, 1893; L. Fletcher, *Nature*, XLVI. 620, 1892.

$MgO.TiO_2$. Ceylon.

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Gersbyite. L. J. Igelström, *Zeits. Kryst. Min.* XXVIII. 310, 1897.
Near lazulite. Sweden.

Gonnardite. A. Lacroix, *Bull. Soc. fran. Min.* XIX. 426, 1896. F. Gonnard, *Compt. Rend.* LXXIII. 1147, 1871.

A zeolite. $(Ca,Na_2)_2Al_2Si_5O_{15}+5\frac{1}{2}H_2O$? Rhombic. Described by Gonnard as mesolite, but it differs from this optically. Puy-de-Dôme.

Graphitite. W. Luzi, *Zeits. f. Naturwiss.* LXIV. 257, 1891, and *Ber. deutsch. chem. Ges.* XXIV.(2), 4093, 1891 (1892); E. Weinschenk, *Zeits. Kryst. Min.* XXVIII. 291, 1897.

A variety of graphite which does not swell up when moistened with nitric acid and ignited. Weinschenk considers it to be merely graphite.

Guanabacoite. See guanabaquite.

Guanabaquite. F. Vidal y Careta, *Crónica Científica, Barcelona,* XIV. 268, 1891.

Given to replace the name cubaite (*q. v.*) for the "cubical quartz" of Guanabacoa, Cuba.

Also includes the "cubical chalcedony" of the same locality (*Ibid.* XIV. 268, 273, 1891; XIII. 293, 1890); this is shown by L. F. Navarro (*Anal. Soc. Españ. Hist. Nat.* XXI. *Actas*, p. 120, 1893,) to be pseudomorphous, possibly after fluorite.

Hainite. J. Blumrich, *Tsch. Min. Mitth.* XIII. 472, 1893.

Silicate of Na,Ca,Ti,Zr. Anorthic. Related to rosenbuschite, &c. Phonolites of N. Bohemia.

Hamelite. T. S. Hunt, *Mineral Physiology and Physiography,* 1886, pp. 194, 334; *Trans. Roy. Soc. Canada,* IV.(3), 9, (1886), 1887.

Hydrated silicate of Al,Fe,Mg. New Brunswick.

Hastingsite. F. D. Adams and B. J. Harrington, *Amer. Journ. Sci.* I. 212, 1896; and *Canadian Record Sci.* VII. 81, 1896. [This vol. p. 244.]

A soda hornblende with the orthosilicate formula $(R_2',R'')_3R_2'''Si_3O_{12}$. Monosymmetric. Hastings Co., Ontario.

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Hauchecornite. R. Scheibe, *Jahrb. preuss. geol. Landesanst. u. Bergakad.*, for 1892, XII. 91, 1893; H. Laspeyres, *Verh. naturhist. Ver. Bonn*, L. 177, 1893. [*Min. Mag.* X. 339.]

$Ni_{11}SbBi_2S_{13}$ or $(Ni,Co,Fe)_7(S,Bi,As,Sb)_8$. **Tetragonal.** Rhenish Prussia.

Hautefeuillite. L. Michel, *Compt. Rend.* CXVI. 898, 1893; and *Bull. Soc. fran. Min.* XVI. 38, 1893. [This vol. p. 162.]

$(Mg,Ca)_3(PO_4)_2+8H_2O$. Monosymmetric. Norway.

Heazlewoodite. W. F. Petterd, *Catalogue of Minerals of Tasmania*, 1896.

Sulphide of Ni and Fe, related to pentlandite.

Hemiopal. H. H. A. Francke, *Min. Nomenklatur*, 1890, p. 81.

Syn. of halbopal and semiopal.

Heulandite baritica. See barium heulandite.

Hoeferite. F. Katzer, *Tsch. Min. Mitth.* XIV. 519, 1895. [This vol. p. 161.]

$2Fe_2O_3.4SiO_2.7H_2O$. Related to the chloropals. Bohemia.

Hydrocalcite. H. B. Kosmann, *Zeits. deutsch. geol. Ges.* XLIV. 155, 1892.

$CaCO_3.2H_2O$. Silesia.

Iddingsite. A. C. Lawson, *Bull. Dept. Geol. Univ. Calif.* I. 31, 1893. F. L. Ransome, *Ibid.* I. 90, 1893. H. H. Arnold-Bemrose, *Quart. Journ. Geol. Soc.* L. 617, 1894. [*Min. Mag.* X. 264.]

Hydrated silicate of Fe,Ca,Mg and Na. Rhombic. Possibly a pseudomorph after olivine. California.

Idrizite. A. Schrauf, *Jahrb. k. k. geol. Reichsanst.* XLI. 379, 1892.

$(Mg_6,Fe)SO_4+(Al_5,Fe_3)_2S_2O_9+16H_2O$. Nearer to quetenite and botryogen than to pickeringite and halotrichite. Idria, Carniola.

Jarrowite. [G. A. Lebour, *57th Rept. Brit. Assoc.* for 1887, 700, 1888]. *British Museum Student's Index*, since 1886. H. A. Miers, this vol. p. 264.

Syn. of thinolite. Jarrow, Durham.

Jodchromate. See dietzeite.

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Josephinite. W. H. Melville, *Amer. Journ. Sci.* XLIII. 509, 1892.

A nickel iron, Fe_2Ni_5, possibly meteoric. Josephine Co. Oregon.

Kaliastrakanite. A. Naupert and W. Wense, *Ber. deutsch. chem. Ges.* XXVI.(1), 873, 1893; C. A. Tenne, *Zeits. deutsch. geol. Ges.* XLVIII. 632, 1896. The name kalium-astrakanite had previously been used by J. K. van der Heide (*Ber. deutsch. chem. Ges.* XXVI.(1), 414, 1893) for the artificial salt. See leonite.

$MgSO_4.K_2SO_4+4H_2O$. Monosymmetric. Prussian salt deposits.

Kaliblödite. Mentioned by C. A. Tenne, *Zeits. deutsch. geol. Ges.* XLVIII. 632, 1896.

Syn. of kaliastrakanite.

Kamarezite. K. Busz, *Verh. naturhist. Ver. Bonn*, L. *Nitz.-ber.* p. 83, 1893; and *Neues Jahrb. Min.* I. 115, 1895. [This vol. p. 108.]

$3CuO.SO_3.8H_2O$. Rhombic. Kamareza, Greece.

Kauaiite. E. Goldsmith, *Proc. Acad. Nat. Sci. Philadelphia*, 105, 1894. [This vol. p. 166.]

$2Al_2O_3.3(K,Na,H)_2O.SO_3$. Hawaii.

Kehoeite. W. P. Headden, *Amer. Journ. Sci.* XLVI. 22, 1893.

$(Zn_3^1+Ca_4^1)_3P_2O_8+2Al_2(OH)_6+21H_2O$. S. Dakota.

Keramite. T. S. Hunt, *Mineral Physiology and Physiography*, 1886, p. 371; and *Trans. Roy. Soc. Canada*, III.(3), 76, (1885) 1886

A clay resulting from the alteration of scapolite. Bavaria.

Klinozoisite. E. Weinschenk, *Zeits. Kryst. Min.* XXVI. 161, 1896. [This vol. p. 237.]

Epidote containing only a little iron, and so agreeing with zoisite in composition. $H_2Ca_4Al_6Si_6O_{26}$. Monosymmetric. Tyrol.

Knopite. P. J. Holmqvist, *Geol. För. Förh.* XVI. 73, 1894. [This vol. p. 158.]

$CaO.TiO_2$ with some Ce_2O_3. Pseudo-cubic. Alnö, Sweden.

Kosmochlor. H. Laspeyres, *Zeits. Kryst. Min.* XXVII. 592, 1897.

Silicate of Cr &c. Probably monosymmetric. From the Toluca meteoric iron.

Kylindrite. A. Frenzel, *Neues Jahrb. Min.* II. 125, 1893.

$6PbS.Sb_2S_3.6SnS_2$ Bolivia.

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Lamprostibian. L. J. Igelström, *Geol. För. Förh.* XV. 471, 1893; and *Zeits. Kryst. Min.* XX. 467, 1894.

Antimonate of Fe and Mn. Sjö mine, Sweden.

Langbeinite. S. Zuckschwerdt, *Zeits. angewandte Chem.* 356, 1891. O. Lüdecke, *Chemiker-Zeitung*, XXI. 264, 1897.

$K_2SO_4.2MgSO_4$. Cubic, tetartohedral (Lüdecke). Prussian salt deposits.

Lawsonite. F. L. Ransome, *Bull. Dept. Geol. Univ. Calif.* I. 301, 1895; and F. L. Ransome and C. Palache, *Zeits. Kryst. Min.* XXV. 531, 1896. [This vol. p. 157.]

$CaO.Al_2O_3.2SiO_2.2H_2O$. Rhombic. California. Piedmont (*Bull. Soc. fran. Min.* XX. 5. 1897). Corsica (*Ibid.* p. 110).

Lembergite. A. Lagorio, *Trav. Soc. Natural. Varsovie, Ann.* VI. *Livr.* XI. 7, 1895. [Abstract in *Zeits. Kryst. Min.* XXVIII. 526, 1897.] J. Lemberg, *Zeits. deutsch. geol. Ges.* XXXIX. 562, 1887. [This vol. p 111.]

Given to Lemberg's artificial "Natronnephelinhydrat."

$4Na_2Al_2Si_2O_8+5H_2O$. Rhombic.

Leonite. C. A. Tenne, *Zeits. deutsch. geol. Ges.* XLVIII. 632, 1896.

To replace kaliastrakanite (*q.v.*).

Lewisite. E. Hussak and G. T. Prior, *Min. Mag.* XI. 80, 1895.

$5(Ca,Fe)O.3Sb_2O_5.2TiO_2$. Cubic. Brazil.

Lindesite. L. J. Igelström, *Zeits. Kryst. Min.* XXIII. 590, 1894. H. Sjögren, *Bull. Geol. Inst. Upsala*, II. 84, 132, 1895. [This vol. pp. 105, 168.]

Shown by Sjögren to be identical with urbanite.

Lorandite. J. A. Krenner, *Math. és term.-tud. Értesitö*, XII. 473, 1894; XIII. 258, 1895; Abstract in *Zeits. Kryst. Min.* XXVII. 98, 1896. [This vol. pp. 32, 168.]

$Tl_2S.As_2S_3$. Monosymmetric. Macedonia.

Lossenite. L. Milch, *Zeits. Kryst. Min.* XXIV. 100, 1894. [This vol. p. 106.]

$2PbSO_4+6(FeOH)_3As_2O_8+27H_2O$. Rhombic. Laurion, Greece.

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Lutecite. A. Michel-Lévy and Munier-Chalmas, *Bull. Soc. fran. Min.* XV. 174, 1892. F. Wallerant, *ibid.* XX. 57, 1897. [*Min. Mag.* X. 256].

A fibrous form of silica.

Mackintoshite. W. E. Hidden and W. F. Hillebrand, *Amer. Journ. Sci.* XLVI. 98, 1893. [*Min. Mag.* X. 341].

$UO_2.3ThO_2.3SiO_2.3H_2O$. Tetragonal. Llano Co., Texas.

Magnetostibian L. J. Igelström, *Zeits. Kryst. Min.* XXIII. 212, 1894.

Antimonate of Mn and Fe. Sjö mine, Sweden.

Magnofranklinite. *Geol. Survey, New Jersey, Final Rept.* II. (1), 14, 1892. A. H. Chester, *Dictionary of the Names of Minerals*, 1896, p. 164.

A local name for the franklinite of Sterling Hill, N.J., which contains little zinc and is highly magnetic.

Maltesite. J. J. Sederholm, *Geol. För. Förh.* XVIII. 390, 1896.

A variety of andalusite resembling chiastolite. Finland.

Manganandalusite. H. Bäckström, *Geol. För. Förh.* XVIII. 386, 1896.

A variety of andalusite containing 6·91 per cent. Mn_2O_3. Sweden.

Mangankiesel. F. Klockmann, *Jahrb. k. preuss. geol. Landesanst. u. Bergakad.* for 1894, XV. p. xxxii. 1895.

A quartz-schist containing much $MnCO_3$. Harz.

Marshite. A Liversidge, *Journ. and Proc. Roy. Soc. N.S. Wales*, XXVI. 328, 1892; abstract by H. A. Miers, *Zeits. Kryst. Min.* XXIV. 207, 1894. [This vol. p. 236.]

Copper iodide. Cubic (Miers). Broken Hill, N.S.W.

Masrite. H. D. Richmond and H. Off, *Journ. Chem. Soc. Trans.* LXI. 491, 1892.

A fibrous alum containing "the element masrium." Egypt.

Mauzeliite. H. Sjögren, *Geol. För. Förh.* XVII. 313, 1895. [This vol. pp. 82, 229.]

$4(Ca,Pb)O.2Sb_2O_5.TiO_2$. Cubic. Sweden.

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Melanostibian. L. J. Igelström, *Geol. För. Förh.* XIV. 583, 1892; and *Zeits. Kryst. Min.* XXI. 246, 1893.

Antimonite of Mn and Fe. Sjö mine, Sweden.

Mesabite. H. V. Winchell, *Trans. Amer. Inst. Mining Engineers*, XXI. 660, 1893.

The ochreous göthite abundant at Mesabi, Minnesota.

Metadesmine. F. Rinne, *Neues Jahrb. Min.* I. 57, 1897. [This vol. p. 343.]

Given to the substances of definite chemical composition and optical properties produced when water is artifically expelled from stilbite (=desmine).

Metanocerite. F. v. Sandberger, *Neues Jahrb. Min.* I. 221, 1892.

A mineral resembling nocerite. Arendal, Norway.

Metascolezite. F. Rinne, *Neues Jahrb. Min.* II. 60, 1894.

A dehydrated form of scolecite. $CaAl_2Si_3O_{10}+2H_2O$. Monosymmetric.

Minervite. A. Gautier, *Compt. Rend.* CXVI. 1173, 1893.

$Al_2O_3.P_2O_5.7H_2O$. A. Carnot (*Ann. des Mines*, VIII. 311, 1895) gives it as a phosphate of Al and K. Grotte de Minerve, France.

Munkforssite. L. J. Igelström. *Zeits. Kryst. Min.* XXVII. 601. 1897. Spelt munkforsite, *Ibid.* XXVIII. 310, 1897.

Phosphate and sulphate of Ca and Al; resembles svanbergite. Sweden.

Munkrudite. L. J. Igelström. *Zeits. Kryst. Min.* XXVIII. 310, 1897.

Phosphate and sulphate of Fe and Ca; resembles svanbergite. Munkerud, Sweden.

Natron-berzeliite. H. Bäckström, *Zeits. Kryst. Min.* XXVI. 102, 1896 (abstract of H. Sjögren's paper).

Syn. of soda-berzeliite (*q. v.*).

Natronrichterite. H. Sjögren, *Geol. För. Förh.* XIV. 253, 1892.

See soda-richterite.

Neptunite. G. Flink, *Geol. För. Förh.* XV. 196, 1893; and *Zeits. Kryst. Min.* XXIII. 346, 1894. O. Sjöström, *Geol. För. Förh.* XV. 393, 1893. [This vol. p. 100.]

$(Fe,Mn)O.(Na,K)_2O.4SiO_2.TiO_2$. Monosymmetric. Greenland.

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Nickel-skutterudite. E. Waller and A. J. Moses, *School of Mines Quart.* XIV. 49, 1892.

(Ni,Co,Fe)As_3. New Mexico.

Northupite. W. M. Foote, *Proc. Acad. Nat. Sci. Philadelphia*, 1895, 408, 1896; and *Amer. Journ. Sci.* L. 480, 1895. J. H. Pratt, *Amer. Journ. Sci.* II. 124, 1896; and *Zeits. Kryst. Min.* XXVII. 418, 1896. [This vol. pp. 159, 226.]

$MgCO_3.Na_2CO_3.NaCl$. Cubic. California.

Pearceite. S. L. Penfield, *Amer. Journ. Sci.* II. 17, 1896; and *Zeits. Kryst. Min.* XXVII. 65, 1896. [This vol. p. 224.]

A name for the arsenical varieties of polybasite. $9Ag_2S.As_2S_3$. Monosymmetric.

Penfieldite. F. A. Genth, *Amer. Journ. Sci.* XLIV. 260, 1892. S. L. Penfield, *Ibid.* XLVIII. 114, 1894. [This vol. p. 43.]

$PbO.2PbCl_2$. Hexagonal. Laurion, Greece.

Pirssonite. J. H. Pratt, *Amer. Journ. Sci.* II. 126, 1896; and *Zeits. Kryst. Min.* XXVII. 420, 1896. [This vol. p. 226.]

$CaCO_3.Na_2CO_3.2H_2O$. Rhombic. California.

Potash-richterite. H. Sjögren, *Bull. Geol. Inst. Upsala*, II. 77, 1895.

The original richterite analysed by Michaelson in 1863.

Prolectite. H. Sjögren, *Bull. Geol. Inst. Upsala*, II. 99, 1895. [This vol. pp. 139, 161.]

Probably $Mg[Mg(F,OH)]_2\,SiO_4$. Monosymmetric. Sweden.

Pseudoboleite. A. Lacroix, *Bull. Mus. d'Hist. Nat. Paris*, p. 39, 1895.

Between boleite and cumengeite. Boleo, Lower California.

Pseudopyrophyllite. F. Löwinson-Lessing, *Verh. russ. min. Ges.* XXXIII. 283, 1895.

$3MgO.4Al_2O_3.9SiO_2.8H_2O$. Rhombic. Urals.

Quartzine. A. Michel-Lévy and Munier-Chalmas, *Bull. Soc. fran. Min.* XV. 166, 1892; F. Wallerant, *Ibid.* XX. 52, 1897. [*Min. Mag.* X. 254.]

A fibrous form of silica.

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Quiroguite. L. F. Navarro, *Anal. Soc. Españ. Hist. Nat.* XXIV. *Actas*, p. 96, 1895. Spelt quirogite in abstracts in *Zeits. Kryst. Min.* XXVIII. 202, 1897; *Neues Jahrb. Min.* I. 452, Ref. 1897; *Bull. Soc. fran. Min.* XX. 168, 1897. [This vol. p. 241.]

$23PbS.3Sb_2S_3$. Tetragonal. Spain. [Probably only galena.]

Ransätite. L. J. Igelström, *Geol. För. Förh.* XVIII. 48, 1896; and *Zeits. Kryst. Min.* XXVII. 604, 1897.

"$3(Mn,Ca,Mg)SiO_3+(Fe,Al)_4Si_3O_{12}$." "Cubic." Sweden.

Raphite. H. How. [T. Egleston, *Catalogue of Minerals*, (1887), 1889, p. 144. A. H. Chester, *Dictionary of the Names of Minerals*, 1896, p. 227. In the British Museum since 1879.]

Synonym of ulexite.

Rathite. H. Baumhauer, *Zeits. Kryst. Min.* XXVI. 598, 1896. [This vol. p. 225.]

A sulpho-salt of Pb,As (and Sb). Rhombic. Binnenthal, Switzerland.

Retzian. H. Sjögren, *Bull. Geol. Inst. Upsala*, II. 54, 1895; *Geol. För. Förh.* XIX. 106, 1897. [This vol. p. 167.]

Hydrated basic arsenate of Mn and Ca; near flinkite. Rhombic. Sweden.

Rhodoarsenian. L. J. Igelström, *Zeits. Kryst. Min.* XXII. 469, 1892.

Hydrated basic arsenate of Mn,Ca and Mg. Sjö mine, Sweden.

Rhodophosphite. L. J. Igelström, *Zeits. Kryst. Min.* XXV. 433, 1895.

Phosphate of Ca, (Mn and Fe) with chloride and sulphate. Sweden. [Part of the analysis given for this has been published (*Bull. Soc. fran. Min.* V. 303, 1882) for manganapatite.]

Rhodusite. H. v. Foullon, *Ber. Akad. Wien*, C. (1), 144, 1891.

Asbestiform glaucophane. Island of Rhodes.

Rœblingite. S. L. Penfield and H. W. Foote, *Amer. Journ. Sci.* III. 413, 1897. [This vol. p. 343.]

$5(H_2CaSiO_4)+2(CaO.PbSO_3)$. New Jersey.

Salvadorite. W. Herz, *Zeits. Kryst. Min.* XXVI. 16, 1896. [This vol. p. 240.]

$FeCu_2(SO_4)_3+21H_2O$. Monosymmetric. Chili.

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Schulzenite. P. Martens, *Actes Soc. Sci. Chili*, V. 87, 1895.

$CuO.2CoO.Co_2O_3.4H_2O$. Resembles wad. Chili ?

Seelandite. A. Brunlechner, *Jahrb. naturh. Landes-Museums, Klagenfurt*, XXII. 192, 1893; "*Carinthia*," *Klagenfurt*, No. 2, 1891.

$MgO.Al_2O_3.4SO_3.27H_2O$. Near pickeringite. Carinthia.

Siderotil. A. Schrauf, *Jahrb. k. k. geol. Reichsanst.* XLI. 380, 1892.

$FeSO_4+5H_2O$. Idria, Carniola.

Sjögrufvite. L. J. Igelström, *Geol. För. Förh.* XIV. 309, 1892; *Zeits. Kryst. Min.* XXII. 471, 1894.

Hydrated arsenate of Mn and Fe. Sjö mine, Sweden.

Soda-berzeliite. H. Sjögren, *Bull. Geol. Inst. Upsala*, II. 92, 1895. [This vol. p. 163.]

$10RO.3As_2O_5$ or $3RO.As_2O_5$. Cubic. Sweden.

Soda-richterite. H. Sjögren, *Bull. Geol. Inst. Upsala*, II. 71, 1895.

To replace the name astochite (*Geol. För. Förh.* XIII. 604, 1891). See natronrichterite.

Stevensite. A. R. Leeds. [A. H. Chester, *Dictionary of the Names of Minerals*, 1896, p. 257.]

Talc pseudomorphous after pectolite.

Stiberite. H. How. [T. Egleston, *Catalogue of Minerals*, 3rd edit. 1892, p. 328. A. H. Chester, *Dictionary of the Names of Minerals*, 1896, p. 257. In the British Museum since 1879.]

Syn. of ulexite.

Stibiotantalite. G. A. Goyder, *Journ. Chem. Soc. Trans.* LXIII. 1076, 1893.

$(Ta,Nb)_2O_5.Sb_2O_3$[?] Rhombic ? Western Australia.

Sulfoborite. A. Naupert and W. Wense, *Ber. deutsch. chem. Ges.* XXVI.(1), 874, 1893. H. Bücking, *Ber. Akad. Berlin*, 967, 1893. K. Thaddéeff, *Zeits. Kryst. Min.* XXVIII. 264, 1897. [This vol. p. 103.]

$3MgSO_4.2Mg_3B_4O_9.12H_2O$. According to Thaddéeff—

$MgSO_4.Mg_2B_2O_5.4\frac{1}{2}H_2O=4MgHBO_3+2MgSO_4+7H_2O$.

Rhombic (Bücking). Prussian salt deposits.

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Sundtite. W. C. Brögger, *Forh. Vid.-Selsk. Christiania*, for 1892, No. 18, 1893. This vol. p. 286.

Syn. of andorite.

Talc-knebelite. See talkknebelite.

Talkknebelite. L. J. Igelström, *Neues Jahrb. Min.* I. 248, 1890.

Knebelite with 4·7 per cent. MgO. Sweden.

Taraspite. C. v. John. *Verh. k. k. geol. Reichsanst.* p. 67, 1891.

Syn. of miemite (var. of dolomite). Tarasp, Switzerland.

Tetragophosphite. L. J. Igelström, *Zeits. Kryst. Min.* XXV. 433, 1895.

Slightly more basic than lazulite. Sweden.

Tiffanyite. G. F. Kunz, *Trans. N. Y. Acad. Sci.* XIV. 260, 1895. [This vol. p. 241.]

A hydrocarbon to which is attributed the phosphorescence of diamonds.

Tilasite. H. Sjögren, *Geol. För. Förh.* XVII. 291, 1895. [This vol. p. 229.]

Fluor-adelite. $2CaO.MgO.MgF_2.As_2O_5$. Anorthic. Sweden.

Tripuhyite. E. Hussak and G. T. Prior, *Min. Mag.* XI. 302, 1897.

$2FeO.Sb_2O_5$. Tripuhy, Brazil.

Urbanite. H. Sjögren, *Geol. För. Förh.* XIV. 251, 1892; and *Bull. Geol. Inst. Upsala*, II. 77, 106, 1895. [This vol. p. 167.]

A monosymmetric pyroxene. $(Ca,Mg)O.SiO_2+Na_2O.Fe_2O_3.4SiO_2$.

Utahlite. G. F. Kunz, *16th Ann. Rept. U. S. Geol. Survey*, for 1894-5, Pt. IV. 602, 1895.

The compact nodular variscite from Cedar Valley, Utah.

Valleite. G. Cesàro, *Bull. Acad. Belg.* XXXII. 536, 1896; XXIX. 508, 1895. [This vol. p. 228.]

A rhombic amphibole near anthophyllite. $(Mg,Ca)O.SiO_2$. New York.

Wardite. J. M. Davison, *Amer. Journ. Sci.* II. 154, 1896. [This vol. p. 226.]

$P_2O_5.2Al_2O_3.4H_2O$. Utah.

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Webnerite. A. W. Stelzner, *Zeits. Kryst. Min.* XXIV. 125, 1894. This vol. p. 286.

Syn. of andorite.

Weldite. W. F. Petterd, *Catalogue of Minerals of Tasmania*, 1896.

Silicate of Al and Na.

Wellsite. J. H. Pratt and H. W. Foote, *Amer. Journ. Sci.* III. 443. 1897.

$(Ba,Ca,K_2)O.Al_2O_3.3SiO_2+3H_2O$. Monosymmetric. Related to phillipsite. North Carolina.

Whartonite. S. H. Emmens, *Journ. Amer. Chem. Soc.* XIV. 209, 1892. S. L. Penfield, *Amer. Journ. Sci.* XLV. 496, 1893.

Shown by Penfield to be nickeliferous pyrites. Sudbury, Canada.

Willyamite. E. F. Pittman, *Journ. and Proc. Roy. Soc. N. S. Wales*, XXVII. 366, 1893. [This vol. p. 236.]

$CoS_2.NiS_2.CoSb_2.NiSb_2$. Cubic. Broken Hill, N.S.W.

Xiphonite. G. Platania, *Atti Accad. Sci. Acireale*, V. 55, 1893. [This vol. p. 168.]

A variety of amphibole. Monosymmetric. Etna.

Zinkmanganerz. A. Brunlechner, *Jahrb. naturh. Landes-Museums, Klagenfurt*, XXII. 194, 1893.

Hydrated manganate of zinc. Carinthia.

Zirkelite. E. Hussak and G. T. Prior, *Min. Mag.* XI. 86, 1895; XI. 180, 1897.

$(Ca,Fe)O.2(Zr,Ti,Th)O_2$. Cubic. Brazil.

August, 1897.

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ABSTRACTS.

The Identity of Chalcostibite (Wolfsbergite) and Guejarite. (S. L. Penfield and A. Frenzel, *Amer. Journ. Sci.*, IV, 27-35, July 1897, 4 figs.; and *Zeits. Kryst. Min.* XXVIII, 598, 1897).—The identity of chalcostibite and guejarite, first suggested before this Society,[1] has now, from a re-examination of the original material, been conclusively proved.

The mineral was first described, from Wolfsberg in the Harz, by Zincken in 1835, under the name Kupferantimonglanz; it was determined by G. Rose to be orthorhombic, but terminal faces were wanting on the prismatic crystals; and an analysis by H. Rose gave to it the formula $Cu_2S.Sb_2S_3$. The name chalcostibite was proposed by Glocker in 1847, and wolfsbergite was given by Nicol two years later; although the latter is perhaps the more familiar name, the present authors adopt, with Dana, the older name chalcostibite. It was not until much later (1891) that a more complete crystallographic description of the mineral was given by Laspeyres.

"Guejarite" was described in 1879 by E. Cumenge[2] from Güejar-Sierra, on the northern slopes of the Sierra Nevada, Spain. The results of his analysis, which were only given to half per cents., led to the formula $Cu_2S.2Sb_2S_3$. C. Friedel noticed at the time that the crystallographic measurements of the prism zone were in agreement with the only zone then known for chalcostibite, but it was only the later measurements of Laspeyres that showed the complete crystallographic identity of chalcostibite and guejarite. Here it may be mentioned that Breithaupt in 1857 described chalcostibite from the "guejarite" locality,[3] giving an analysis and an angular measurement. This was apparently overlooked by Cumenge, nor is it mentioned by the present authors.

The position adopted by Friedel for the guejarite crystals was the same as Rose's position for chalcostibite, the striated prismatic zone being

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[1] "On wolfsbergite (chalcostibite) from Bolivia, and the probable identity of wolfsbergite and guejarite," by L. J. Spencer. Read April 14th, 1896. See this volume, pp. x, 190.

[2] Abstract in *Min. Mag.*, IV, 64.

[3] The locality, Lanteira, given by Breithaupt, is about 16 or 18 miles to the east of Güejar-Sierra.

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placed vertically and the perfect cleavage being $b\{010\}$. When placed in the new position,[1] in which the prismatic zone is parallel to the macroaxis b and the perfect cleavage is $c\{001\}$, the forms given by Friedel have the following indices:—$c\{001\}$, $b\{010\}$, $g\{201\}$, $i\{302\}$, $d\{101\}$, $h\{203\}$, $u\{061\}$, $t\{021\}$; and, from his measurements, the axial ratios become—

$$a : b : c : = 0{\cdot}5242 : 1 : 0{\cdot}6377.$$

From an examination of Cumenge's original material, the present authors show that the crystallographic measurements agree closely with Friedel's determinations, but that the analyses (II, III and IV by Frenzel) are in accordance with the formula $Cu_2S.Sb_2S_3$, and not $Cu_2S.2Sb_2S_3$, as given by Cumenge. The excess of antimony shown in Cumenge's analysis (quoted under I below) was probably due to the presence of stibnite,[2] which, as noted by Cumenge himself, closely resembles chalcostibite in colour, lustre, habit and cleavage. In collecting material for the present analyses each crystal was qualitatively tested for copper, in order to make sure that no stibnite was present.

	I. (Cumenge.)	II.	III.	IV.	V.	VI.	VII. (Calculated.)
S ...	25·0	26·28	—	26·12	25·29	26·20	25·87
Sb ...	58·5	48·86	48·50	48·44	48·30	48·45	48·50
Cu ...	15·5	24·44	25·92	25·23	25·36	24·72	25·63
Pb ...	trace	0·58	—	0·32	—	—	—
Fe ...	0·5	0·42	—	0·49	1·23	—	—
Zn ...	—	—	—	0·18	—	—	—
	99·5	100·58		100·78	100·18	99·37	100·00
Sp. gr....	5·03	4·96	—	—	5·015	—	—

Under V is given T. Richter's analysis of Breithaupt's Spanish chalcostibite; and under VII the calculated percentage composition of $Cu_2S.Sb_2S_3$.

Chalcostibite from Bolivia. The identity of chalcostibite and guejarite was in the first place suggested by the examination of a specimen sent to the British Museum labelled as guejarite. This was one of two specimens obtained by the late Theodore Hohmann from the Pulacayo mine, Huanchaca, Bolivia. It was found that the angular measurements, the presence of copper, the colour, lustre, hardness, crystal habit and the perfect cleavage

[1] See this volume, p. 188.

[2] Stibnite occurs at Güejar-Sierra, according to P. Sampayo and A. A. de Linera. —*Revista Minera, Madrid*, VIII, 274, 1857.

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observed for these crystals agreed equally well with the descriptions of both chalcostibite and guejarite. Owing, however, to the small amount of material, a quantitative analysis could not be made; this has now been done by Frenzel, and his results, given in Column VI above, agree closely with the formula $Cu_2S.Sb_2S_3$.

Both of the Bolivian specimens consist of a matrix of pyrites, quartz and tetrahedrite. That examined by Penfield shows numerous bright, prismatic crystals, averaging 1 mm. in diameter and 2 mm. in length, which are highly modified and rich in terminal faces. On these crystals he observed 20 forms, 13 of which are new; and, from the very good angles $863 : \bar{8}63 = 126°21'$ and $863 : \bar{8}6\bar{3} = 138°21'$, calculates $a : b : c = 0{\cdot}5312 : 1 : 0{\cdot}63955$. The observations made on the British Museum specimen, which are incorporated in the present paper, were less complete, as here the crystals were smaller and terminal faces were rare; on these blade-shaped crystals the following forms were observed: $c\eta idg\alpha\beta\gamma\delta\varepsilon$, the last five being new.

In the present paper, tables of angles measured by Penfield, C. Friedel, H. Laspeyres, G. G. Schott (on a crystal in the Munich collection) and L. J. Spencer are given; many of these vary from the calculated values owing to the striated character of some of the faces, but others are very close. Pyramids with complicated indices seem to be rather characteristic for chalcostibite, the forms $q\{863\}$ and $p\{6.12.7\}$ occurring on the Wolfsberg as well as on the Bolivian crystals. In the following table the forms observed by various authors are brought together. Here Laspeyres' $p\{7.14.8\}$ and $r\{7.21.27\}$ are given as $p\{6.12.7\}$ and $r\{134\}$ respectively.

b {010}	Δ_3 {205}	g {201}	p {6.12.7}	σ {4.12.5}
c {001}	e {307}	f {011}	μ {136}	τ {261}
l {130}	j {102}	s {065}	r {134}	α {233}
Δ {209}	h {203}	t {021}	ν {133}	β {354}
Δ_1 {207}	d {101}	u {061}	π {265}	γ {474}
Δ_2 {103}	i {302}	q {863}	ρ {263}	δ {475}
				ε {476}

L. J. S.

Edingtonite from Sweden. This rare zeolite, previously only known as small crystals from Old Kilpatrick, in Dumbartonshire, was determined by Haidinger in 1825 to be tetragonal with sphenoidal hemihedrism, and $a : c = 1 : 0{\cdot}6725$. The original analysis by Turner was incorrect, and that published by Heddle in 1855 gave the formula as being probably

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$BaO.Al_2O_3.3SiO_2.3H_2O$. The same mineral has recently been found in large crystals at the manganese mines of Böhlet in Vestergötland.

Otto Nordenskiöld (*Geol. Fören. i Stockholm Förh.* XXVII, 597-600, 1895; and *Bull. Soc. fran. Min.*, XXVIII, 396, 1895) has found these new crystals to be orthorhombic and hemihedral. The forms present are {001}, {110}, {111}, {1$\bar{1}$1}, {121} and {12$\bar{1}$}; the complimentary forms {121} and {12$\bar{1}$} are not found on the same crystal. The measured angles agree closely with Haidinger's determinations, as may be seen from the axial ratios; they are also close to those of natrolite and scolecite.

Edingtonite, $a : b : c = 0{\cdot}9872 : 1 : 0{\cdot}6733$
Natrolite, $a : b : 2c = 0{\cdot}9785 : 1 : 0{\cdot}7072$
Scolecite, $a : b : 2c = 0{\cdot}9763 : 1 : 0{\cdot}6868$; $\beta = 89°18'$

The habit of the crystals in being prismatic differs from that of the Scotch mineral. There is a perfect prismatic cleavage ($mm' = 89°16'$), and one less perfect parallel to the basal plane. Detailed optical determinations are given in the paper. The plane of the optic axes is (010), and the acute negative bisectrix is parallel to the c' axis. For sodium light, $2E_a = 87°17'$, $2V = 52°55'$, $\alpha = 1{\cdot}5370, 1{\cdot}5395$, $\beta = 1{\cdot}5492$, $\gamma = 1{\cdot}5540$.

G. Lindström (*Öfvers. Vetensk.-Akad. Förh. Stockholm*, LIII, 469-472, 1896) gives an analysis (I) which proves the identity of these crystals with the Scotch edingtonite.

	SiO_2.	Al_2O_3.	Fe_2O_3.	BaO.	CaO.	MnO,MgO.	Na_2O.	K_2O.	H_2O.	Cl.	Total.
I.	36·37	20·06	0·04	29·99	0·16	0·06	0·20	0·21	13·12	trace	100·21
II.	36·98	22·63	—	26·84	trace	—	trace	—	12·46	—	98·91

The molecular ratios Al_2O_3 : BaO(CaO, alkalies) : SiO_2 : $H_2O = 1 : 1 : 3 : 3{\cdot}7$, agree with those of Heddle's analysis (II) with the exception of the water. At 100° there is a loss of 3·82 per cent. water. Sp. gr = 2·782 (Lindström), 2·776 (Nordenskiöld).

A. Lacroix (*Bull. Soc. fran. Min.*, XIX, 422-426, 1896) attributes the uniaxial character of the Scotch edingtonite, as observed by Mallard and himself, to twinning about the pseudo-tetragonal axis; he shows that something of the same sort is exhibited by natrolite. L. J. S.

Asbestos and Asbestiform Minerals, (G. P. Merrill, *Proc. U. S. National Museum*, XVIII, (1895), 281-292, 1896).—As commercially used the name asbestos now covers at least four distinct minerals which have in

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common only a fibrous structure and more or less fire- and acid-proof properties; these are:—

1. Tremolite or asbestos proper.
2. Serpentine (amianthus).
3. Anthophyllite.
4. Crocidolite.

The first two are as a rule readily distinguished by the silky fibres and greater flexibility of asbestiform serpentine; but tremolite and anthophyllite can only be distinguished by optical (extinction angle) and chemical means, and it is here shown that much of what is labelled in collections as asbestos is really anthophyllite.

The fibrous structure of these minerals is, in many cases, secondary, and due to a process of shearing; the original mineral, an amphibole and probably sometimes a pyroxene, being drawn out in the direction of the vertical axis, giving rise to fibres bounded by the prism cleavages of amphibole. Cases are cited of asbestos coating the surfaces of slickensides. L. J. S.

Thaumasite from West Paterson, New Jersey. (S. L. Penfield and J. H. Pratt, *Amer. Journ. Sci.*, I, 229-233, 1896; and *Zeits. Kryst. Min.*, XXVI, 262, 1896). Owing to the anomalous composition of thaumasite, which has previously only been known from Sweden, its occurrence at a new locality is of interest. At Paterson, New Jersey, it has been found in considerable quantity with zeolites in a trap rock. It here consists of an aggregate of prismatic crystals, sometimes loose, but more often firm, and resembling white alabaster in appearance. There is a distinct prismatic cleavage with angles of about 60°; the mineral is optically uniaxial and negative; the crystalline system is therefore hexagonal. Sp. gr. 1·875–1·887.

Analysis I gives the usual formula $CaSiO_3.CaCO_3.CaSO_4.15H_2O$. At 150°, $13H_2O$ is expelled, and the remainder goes off at four higher temperatures; the structural formula is therefore written as—

$$[(CaOH)CO_2]\,[(CaOH)SO_3]\,[CaOH]\,HSiO_4+13H_2O.$$

The alkalies are present as impurities, since they are dissolved out, together with a little thaumasite, by water.

	SiO_2.	CO_2.	SO_3.	CaO.	H_2O.	Na_2O.	K_2O.	Al_2O_3,Fe_2O_3.	Total.
I.	9·26	6·82	13·44	27·13	42·77	0·39	0·18	—	99·99
II.	8·95	8·25	12·60	27·30	43·70	—	—	0·30	101·10

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F. Pisani (*Bull. Soc. fran. Min.*, XIX, 85-87, 1896) gives analysis II, of the material from this locality; he gives the chemical formula as $2CaO.(SiO_2,CO_2)+CaO.SO_3+16H_2O$, and the system as being possibly monosymmetric. L. J. S.

Dehydration of Stilbite. (F. Rinne, *Neues Jahrb. Min.*, I, 41-60, 1897). When stilbite ($CaAl_2Si_6O_{16}+6H_2O$) is placed in concentrated sulphuric acid, the loss of water is accompanied by a progressive change in the optical characters of the crystals; the optic axes vary their positions, passing through uniaxial positions four times. These changes, which also take place when the crystals are heated, are gradual, but the following stages can be distinguished:—

Temperature.	$CaAl_2Si_6O_{16}+$	Uniaxial on	System.
125°	$5H_2O$	$(\bar{2}01)$	Monosymmetric
150°	$4H_2O$	(010)	,,
185°	$3H_2O$	(001)	,,
250°	$2H_2O$	$(\bar{2}01)$	Passage to orthorhombic
350°	H_2O	—	Orthorhombic
Ignition	—	—	Amorphous

The name *metadesmine* is given to these dehydrated forms. These changes are analogous to those which take place in heulandite. By the action of dilute acids, birefringent forms of silica are produced as in heulandite (this vol. p. 243). L. J. S.

Rœblingite. (S. L. Penfield and H. W. Foote, *Amer. Journ. Sci.*, III, 413-415, 1897). This new mineral is of interest in being the first sulphite that has been observed in nature. It occurs as white, compact masses filling cavities in axinite, which forms veins in the garnet rock of the zinc deposits of Franklin, New Jersey. The associated minerals are sphene, zircon, phlogopite, willemite, datolite, barytes, caswellite, calcite, mispickel, blende, rhodonite and rhodochrosite. Under the microscope, rœblingite is seen to consist of an aggregate of minute prismatic crystals with straight extinction and weak birefringence. The hardness is a little below 3; sp. gr. 3·433. The powdered mineral is

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easily soluble in dilute acids with separation of gelatinous silica and evolution of sulphur dioxide. The mean of two analyses by Foote is:—

SiO_2.	SO_3.	PbO.	MnO.	CaO.	SrO.	K_2O.	Na_2O.	H_2O.	Total.
23·58	9·00	31·03	2·48	25·95	1·40	0·13	0·40	6·35	100·32

The formula is given somewhat doubtfully as—

$$H_{10}Ca_7Pb_3Si_3S_2O_{28} = 5H_2CaSiO_4 + 2(CaO.PbSO_3).$$

It is not probable that the mineral is a mixture, or contains much impurity. L. J. S.

Pseudogaylussite from Holland (F. J. P. van Calker, *Zeits. Kryst. Min.*, XXVIII, 556-572, 1897).—Spheroidal groups of crystals, closely resembling the well-known pseudomorphs from Sangerhausen in Thuringia and other localities, have been found embedded in alluvial clay at Onderdendam, in the province Groningen. The acute pyramidal crystals are of a yellowish colour, and the surfaces are rough and curved. In the interior they consist of a cellular aggregate of differently orientated calcite grains; analysis shows the presence of 89·9462 per cent. of calcium carbonate. Pseudogaylussite is also recorded from Kwadyk and Friesland, in Holland.

A review is given of the literature of these pseudomorphs, and the evidence supplied by the chemical composition and external form is discussed. No definite conclusion is arrived at as to what was the original mineral, which has been variously assumed to be gaylussite (Breithaupt, 1836), celestite (Des Cloizeaux, 1843; compare Miers, this volume, p. 264), gypsum (Kenngott 1870), anhydrite (Groth, 1878), and a hypothetical tetragonal chloro-carbonate of calcium (Dana, 1884). The author has failed to detect strontium by spectroscopic methods; and the presence of a little sodium carbonate, and the porous structure of the pseudomorphs, seem to suggest that gaylussite was the original mineral. Several angles have been measured, but owing to the roughness and curvature of the faces the variations are considerable, amounting to 10° or even 20°. From the comparison of these angles with the angles between the gaylussite forms {011} and {$\bar{1}$12} and the celestite forms {133} and {144} no conclusions can be drawn. L. J. S.

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NOTES AND COMMENTS.

THIS year has seen the close of the careers of two eminent Mineralogists. Alfred L. O. L. Des Cloizeaux, who had been since 1876 Professor of Mineralogy at the Museum of Natural History in Paris, and Gustav A. Kenngott, who was for nearly 40 years Professor of Mineralogy at Zürich.

In Professor Des Cloizeaux the Mineralogical Society loses one of its most distinguished Corresponding Members.

Another Corresponding Member has been taken from the Society in the person of Professor J. J. S. Steenstrup, of Kopenhagen, who died at the advanced age of 84.

Death has also robbed us of one of our Vice-Presidents, Dr. Samuel Haughton, who was Professor of Geology at Trinity College, Dublin, from 1851 to 1881.

Even more recently we hear with great regret of the death of Dr. M. F. Heddle, a Past-President of the Society, and one of its founders and most active members. He died on Nov. 19th.

Some notice of the life and work of Des Cloizeaux and Heddle will be given in the next number.

We regret also to record the death on May 25th, at the age of 75, of Dr. Lars J. Igelström, an indefatigable mineralogist, who added the names of many new species to the science.

Also of Samuel Allport, well known as one of the pioneers of microscopical petrology, who died on the 7th of July, aged 81.

Among recent appointments are the following:—Dr. Beckenkamp becomes Professor of Mineralogy at Würzburg, and is succeeded at Mülhausen by Dr. Osann, of Heidelberg; Professor A. J. Moses is appointed to the Chair of Mineralogy in Columbia College; and Mr. C. H. Warren becomes Instructor in Mineralogy in the Sheffield Scientific School of Yale University; Professor A. de Lapparent has been elected a Member of the Paris Academy of Sciences in succession to the late Professor Des Cloizeaux.

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OBITUARIES.

Gustav Adolf Kenngott.

THE following particulars of the life and work of this well-known mineralogist are mainly derived from an obituary notice by U. Grubenmann, in the *Vierteljahrsschrift d. Naturforschenden Gesellschaft in Zürich*, XLII. pp. 74-9:—

Gustav Adolf Kenngott was born on January 6th, 1818, at Breslau. In the university of his native town he studied mathematics and natural science, and in 1844 became Privatdocent for Mineralogy, Crystallography and Geognosy. In 1850 he removed to Vienna, and in the winter of that year obtained the Professorship in Natural Science in the Oberrealschule at Pressburg. In 1852 he returned to Vienna as Custos-Adjunkt in the Hofmineralienkabinett, which position he held until 1856, when he was elected Professor of Mineralogy in the Polytechnic School in Zürich, and a year later obtained the ordinary Professorship in the University. These posts he held until his retirement in 1893. What use Kenngott made of time and opportunity in the interests of his tutorial work, in order to further the advance of mineralogy, may be judged from the list of his published works, which occupies seven pages appended to his obituary notice.

He was the author of various text-books on crystallography, mineralogy and petrology, while his book, *Die Minerale der Schweiz*, Leipzig, 1866, remains the standard work of reference for Swiss minerals. His first published papers relate chiefly to crystallography, but his subsequent contributions to mineralogy are for the most part devoted to the description of the character of particular mineral species. From his papers and his method of teaching it is clear that throughout his career Kenngott directed his efforts rather to accurate observation and grasp of detail than to the pursuit of brilliant generalisations. He died on March 14th, 1897.

Samuel Haughton, M.D., F.R.S.

Samuel Haughton was born December 21st, 1823, at Carlow, in which town his father owned extensive flour mills.

He entered Trinity College, Dublin, and in 1843 was first Senior Moderator in Mathematics. He obtained his Fellowship in the following year, at the very early age of 21. He at once took Orders, as at that date two only of the Fellows could be laymen. At first he devoted himself to

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Molecular Mechanics, and in 1848 received the Cunningham Medal of the Royal Irish Academy for his *Memoir on the Equilibrium and Motion of Solid and Fluid Bodies*. He also worked much on Tidal questions.

In 1851 the Professorship of Geology in the University fell vacant, owing to the appointment of Oldham to the Superintendentship of the Indian Geological Survey.

Haughton took the post, which thus connected him with the then rising Engineering School. At this time began his long and intimate connection with Professor Galbraith, another of the staff of that School. The two Professors brought out together a series of Manuals of Science, which had a great popularity. The two also threw themselves with great zeal into the Military Classes, in preparation for the Commissions at Woolwich, thrown open at the time of the Crimean War.

In 1854 Haughton took up Chemistry, and that led on to Medicine, and he became Registrar of the Medical School. This Journal, however, is hardly the place in which to deal with his researches into Animal Mechanics.

He held his Geological Professorship for 30 years, till 1881, when he became a Senior Fellow.

In his Geological work he principally dealt with Chemical Petrology. His analyses, however, were not minutely exact; in his analyses of felspars he often estimated all the alkalies together, and then proceeded to treat the results mathematically, as if all the data were rigorously correct. The outcome of this was that his conclusions were somewhat sharply criticised.

His papers on the Granites of Donegal are the best examples of his methods of calculating rock constituents.

The number of his papers down to 1884 in the Royal Society Catalogue is no less than 173.

He was elected F.R.S. in 1858; he received Honorary Degrees, not only from home, but also from foreign Universities. He was an original Member of the Mineralogical Society, and one of its Vice-Presidents from its institution in 1876 to the present year.

His death occurred on October 31st, 1897.

He married his first cousin, who predeceased him, and left three sons and one daughter.

Dr. Haughton leaves behind him the memory of one of the warmest of friends; of him also it might almost be said that in Science at least *Nihil tetigit quod non ornavit.* R. H. S.

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INDEX TO VOL. XI.

(See also "List of New Mineral Names," p. 323, and list of "British Pseudomorphs," p. 279.)

Absorption brushes in epidote, 97.
Adams (F. D.)—Nepheline-syenite, Ontario, 46.
———— and Harrington (B. J.)—Hastingsite, 244.
Ægirite, Greenland, 101.
Albite, cleavage and parting planes, 43.
Aleksyeev (V.)—Alexjejewite, 236.
Alexjejewite, 236.
Allport (S.)—Death of, 345.
Alnö (Sweden), nepheline-syenite, etc., 250.
Alnöite, 251.
Alston "satin spar," 184.
Altaite, Burma, 215.
Aluminium phosphates, 4, 16, 226, 332, 336.
Alumino-silicates, constitution of, 111.
Alunite, Bolivia, 298.
Amianthus, 342.
Amphibole, soda-, 35, 244.
Amphibolites, Piedmont, 260.
Analcite, constitution of, 38.
———— in monchiquites, 262.
———— group of rocks, 262.
Anatase in rocks, 262.
Andorite, 286.
Andradite, titaniferous, Ontario, 244.
Anhydrite, artificial, 45.
Anglesey, basic ferric sulphate, 13.
Anglesite, cryst., 197.
Anorthoclase, Massachusetts, 252.
———— Vulcano, 35.
———— -augite rock, Vulcano, 35.
Anthophyllite, asbestiform, 342.
————————, Bengal, 118.
Apatite in peridotites, Bengal, 117.
Aplite, xenotime, &c., in, 306.
Apophyllite, constitution, 38.
———— ————, S. Africa, 318.
Aragonite and calcite, massive, 184, 165.
Argyrodite, Bolivia, 40.
Artificial anhydrite, 45.
———— boleite, cumengeite and percylite, 164.
———— powellite, 164.
———— silica, 243, 343.
Arzruni (A.) and Thaddéeff (K.)—Celestite, 234.
Asbestiform minerals, 341.
Asterism in corundum, 52.
Augelite, Bolivia, 16.
Augite, Vulcano, 35.

Bäckström (H.)—Leucite rocks in the Lipari Is., 255.
Baddeleyite, Brazil, 110, 39.
Bagotite, 323.
Ball (V.)—Obituary, 92.
Barlow (W.) — Homogeneous structures and the symmetrical partitioning of them, 119.
———— Homogeneous structures and circular polarisation, xvi.
Barytocelestite, 235.
Basalt, Montana, 253.
Bauer (M.)—Edelsteinkunde, 220, 92.
———— Jadeite, Burma, 160.

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Bauer (M.) Jadeite, "Tibet," 241.
Baumhauer (H.)—Rathite, 225.
Beckenkamp (J.)—345.
Berkeley (Earl of)—Determination of density, 64.
Bertrandite, Bohemia, 106.
Beryl, Bohemia, 106.
Berzeliite, chem., 10.
Binnenthal, rathite, 225.
Binnite, 77.
Biotite, altered, 243.
——— -kyanite-cordierite rock, 141.
Bleinierite after zinckenite, 23.
Blödite, Punjab, 314.
Blue ground, S. Africa, 321.
Boleite, artificial, 164.
———, N. S. Wales, 165.
Bolivia, 16, 40, 298, 339.
Bonney (T. G.)—Cone-in-cone structure, 24.
Bostonite, 247, 249.
Bournonite, cryst., 228.
——— Bolivia, 22.
Box-stones, 43.
Brauns (R.)—91.
——— artificial anhydrite, 45.
Brazil, 80, 176, 302.
Breithauptite, cryst., 107.
British Mineralogical Society, 184.
——— Museum, Introduction to the Study of Rocks, 148.
——— pseudomorphs, 263.
Brögger (W. C.)—Dyke rocks near Christiania, 114.
——— Triassic eruptive rocks of S. Tyrol, 155.
Broken Hill, N. S. W., 165, 236.
Brown (A. P.)—Pyrites and marcasite, 105.
Brown (J. B.) & Judd (J. W.)—Rubies of Burma, 232.
Brush (G. J.) — Determinative mineralogy, 219.
Bücking (H.)—Sulfoborite, 103.
Building materials in the Vienna Museum, 34.
Burma, 160, 215, 232.
Busz (K.)—146.
Busz (K.)—Breithauptite, 107.
——— Caledonite, 108.
——— Kamarezite, 108.
——— Pyrrhotite, 109.
——— Picrite, Devon, 154.

Cacoxenite, chem., 8.
Calaverite, Colorado, 235.
Calcite, etching, 242.
——— and aragonite, massive, 184, 165.
——— primary in eruptive rocks, 250.
Caledonite, Leadhills, cryst., 108.
Calker (F. J. P. van)—Pseudogaylussite, 344.
Canfieldite, 40.
Caryinite, chem., 162.
Cassiterite, cryst., 107; Bolivia, 299.
Caswellite, 243.
Cataforite, 115, 250.
Catapleiite, Greenland, 101.
Celebes, leucite rocks, 36.
Celestite, cryst., 234.
Cerussite coated with galena, 235.
Cesàro (G.)—Valleite, 228.
Chabazite, constitution, 37.
Chalcanthite, Bolivia, 23.
Chalcophanite, 44.
Chalcostibite, cryst., 188.
——— Bolivia, Spain, 338.
Chemical crystallography (Fock), 95.
Chester (A. H.)—Caswellite, 243.
Chili, 104, 240.
Chondrodite, cryst., 138.
Christiania, rocks, 114, 156, 250.
Chromite deposits, 112.
Chrustchoff (K. von)—32.
Church (A. H.)—Chemical study of arsenates and phosphates, 1.
——— ——— Basic ferric sulphate from Anglesey, 13.
——— ——— Determination of density, v.
Cinnabar gravels of Tripuhy, 179.
Clarite = enargite, 75.
Clarke (F. W.)—Constitution of zeolites, 37.
——— ——— Garnet, 235.
Clinoclase, chem., 4.

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Clinohumite, cryst., 138.
Clinozoisite, 237.
Cole (G. A. J.)—Hullite, 229.
Concretions in sandstone, 42.
Cone-in-cone structure, 24.
Constitution of zeolites, 37.
Cooksey (T.)—Opal from N. S. Wales, 244.
Cordierite rock, Himalayas, 141.
Corrosion of minerals in magmas, 145.
Corundum, alteration, 52, 233.
——— structure planes, 49.
——— Burma, 232.
——— -rocks, India, 57.
Crocidolite, asbestiform, 342.
Crossite, 35.
Cryptopyramid, 98.
Crystal angles, variation of, in celestite, 234.
——— structure, 119, xvi.
——— systems, 150.
Crystallography, chemical, 95.
——— for beginners (Woodward), 222.
Crystals, Morphology of (Maskelyne), 93.
Cubic system, structure, 120.
Cumengeite, artificial, 164.

Dana (J. D.)—Obituary of, 89.
Darapskite, cryst., 104.
Darling (C.)—Analysis of mica, 209.
Daubrée (G. A.)—Obituary of, 146.
Davison (J. M.)—Wardite, 226.
Delessite, Cantyre, 28.
Density, determination of, v., 64, 186.
Derby (O. A.)—Monazite and xenotime in rocks, 304.
Derbylite, 176, 85.
Des Cloizeaux (A.)—Death of, 345.
Determinative mineralogy, 219.
Diamond in garnet, xvii.
——— phosphorescent, 241.
Dietzeite, cryst., 104.
Differentiation in magmas, 38, 112, 114, 251.
Diopside, chrome-, Montana, 253.
Double salts, 300.
Dudgeon (P.)—Mispickel form Kirkcudbright, 15.
——— Obituary of, 30.
Dune sands of Holland, 113.
Dungannon (Ontario), 46, 244.
Dyke-rocks, Christiania, 114.

Eakle (A. S.) and Muthmann (W.)—Schneebergite, 229.
Edingtonite, Sweden, xi. 340.
Elæolite-syenite, Ontario, 46, 244; Monchique, 246; Alnö, 250; Texas, 248.
Enargite, cryst., 69, 196.
Enclosures in crystals, xvi. xvii. 44, 199, 233, 296.
English (G. L.)–Catalogue of minerals, 33.
Enstatite and humite, 139.
Epididymite, 100.
Epidote, optics, 97, 245.
——— and zoisite, 237.
Epistilbite, constitution, 37.
Etching, augelite, 19; calcite, 242; corundum, 53.
Euchroite, chem., 1.
Euphyllite, India, 58.

Famatinite, 77.
Faujasite, constitution, 37.
Fayalite, opt., 240.
Felsite-porphyry, New Brunswick, 253.
Fernando Noronha, monchiquite, 171.
Ferric sulphate, basic, Anglesey, 13.
Fibrolite-rock, India, 60.
Fletcher (L.)—Introduction to the study of rocks, 148.
Flink (G.)—New minerals from Greenland, 100.
Fluor-adelite, 229.
Fluorine and hydroxyl in minerals, 41.
Fock (A.)–Chemical crystallography, 95.
Foote (A. E.)—Death of, 146.
Foote (H. W.) and Penfield (S. L.)—Rœblingite, 343.
Foote (W. M.)—Northupite, 159.
Forbes (E. H.)—Epidote, 245.

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Forbes (E. H.) and Penfield (S. L.)—Olivine group, 239.
Foresite, constitution, 37.
Foster (C. le N.)—Diamond in garnet, xvii.
Foullon (H. v.)—Obituary, 217.
France, mineralogy of, 218.
Franckeite, 41.
Frenzel (A.) and Penfield (S. L.)—Identity of chalcostibite and guejarite, 338.
Friedel (C.)—Artificial cumengeite, boleite and percylite, 164.
Fuchsite, India, 58.
Futterer (K.)—91.

Gabbro, metamorphosed, Zermatt, 256.
Gadolin (A.)—Crystal systems, 150.
Garnet group, 238.
——— simulating jade, 235.
——— -rock, N. S. Wales, 63.
Gismondite, constitution, 37.
Glaucophane-eclogite, Zermatt, 257.
Glencullen (Co. Wicklow), mica, 209.
Glockerite, chem., 14.
Gmelinite, constitution, 37.
Gneiss, monazite, etc., in, 304.
Gold, Burma, 215.
—— in granite, 227.
—— moss-, 101.
—— origin of nuggets, 101.
—— hexagonal forms, 102.
—— moiré-métallique, 103.
—— condition in veins, 101.
Granite, monazite, etc., in, 307; gold in, 227.
Green (A. H.)—Obituary, 147.
Greenland, minerals, 100.
Grorudite, 115, 249.
Groth (P.)—Gadolin's crystal systems, 150.
Guejarite = chalcostibite, 338.
———— Bolivia, 23.
Gypsum and anhydrite, artificial, 45.
——— with fluid enclosures, Sicily, 44.
Hackman (V.) and Kraatz-Koschlau (K. v.)—Elæolite-syenite, 246.
Hæmatite, cryst., Brazil, 85.
———— pseudomorphs, 269.
Hamberg (A.)—Etching of calcite, 242.
Hanksite, chem., 227.
Harrington (B. J.) and Adams (F. D.)—Hastingsite, 244.
Harrison (W. J., Junr.)—Prehnite in Wales, 198.
Hartley (W. N.)—Analysis of mica, 210.
Hastingsite, 244.
Haughton (S.)—Obituary of, 346.
Haushofer (C. v.)—Death of, 32.
Hautefeuillite, 162.
Heavy fluids for the separation of minerals, 44, 114, 228.
Heddle (M. F.) Death of, 345.
———— and Thomson (J. S.)—Delessite from Cantyre, 28.
Henderson (J. A. L.)—Apophyllite in S. Africa, 318.
Henderson (J. M. C.)—Mica-syenite in Saxony, 259.
Herderite, chem., 42.
Herschel (A. S.)—Crystal models, ix.
Herz (W.)—Salvadorite, 240.
Heteromorphite, 195.
Heulandite, action of acids on, 243.
———— constitution, 37.
Hidden (W. E)—Peridote in pyrope, &c., xvi.
Highwood Mtns. (Montana), 151,
Hillebrand (W. F.)—Calaverite, 235.
Hintze (C.)—Handbuch der Mineralogie, 217.
Hobbs (W. H.)—Volcanite, 35.
———— Cerussite, 235.
Hoeferite, 161.
Hoffmann (G. C.)—Native iron from Ontario, 160.
Högbom (A. G.)—Nepheline-syenite from Alnö, 250.
Holland, 113, 344.
Holland (T. H.)—Mica-hypersthene-hornblende-peridotite, from Bengal, 117.
Holland (T. H.)—Phosphatic mica-peridotites from Bengal, 117.

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Holmquist (P. J.)—Knopite, 158.
——————— Pyrochlore, 231.
Homogeneous structures, 119.
Hornblende, Montana, 254.
——————— alkali, 35, 244.
Hortonolite, opt., 240.
Howe (W. T. H.) and Penfield (S. L.) —Chondrodite, etc., 161.
Hullite, 229.
Humite series, 137, 161.
——— Zermatt, 258.
Hussak (E.)—Baddeleyite from Brazil, 110.
——————— Perofskite-magnetic-rock, 117.
——————— & Prior (G. T.)—Lewisite and zirkelite, 80.
——————————— Derbylite, 176.
——————— ——— ——— Tripuhyite, 302.
Hutchinson (A.)—Pyrites from Cornwall, xv.
——————— Calcite from Cleator Moor, xvi.
——————— Epidote from the Mourne Mtns., xvii.
Hydrofranklinite = chalcophanite, 44.
Hydronephelite, 37, 112.
Hydroxyl and fluorine in minerals, 41.

Idocrase, chem., 230.
Igelström (L. J.)—Lindesite & pyrrho arsenite, 105. Death of, 345.
Igneous rock masses, form of, 156.
Ijolite, 47.
Ilmenite-norite, Norway, 38.
Iron, native, Ontario, 160.

Jablonowskische Gesellschaft, prize, 146.
Jacupirangite, 86, 110, 117.
Jadeite, Burma, 160.
——— "Tibet," 241.
——— -plagioclase-nephelite rock, 242.
Jarrowite, 264, 328.
Johnstrup (F.)—Obituary, 32.
Judd (J. W.)—Structure planes of corundum, 49.
——————— Simple massive minerals, 56.
——————— and Brown (C. B.)—Rubies of Burma, 232.

Kaliophilite, 111.
Kamarezite, 108.
Kaolin, xenotime, etc., in, 304.
Karrer (F.)—Building materials in the Vienna Museum, 34.
Katzer (F.)—Hoeferite, 161.
Kauaiite, 166.
Kenngott (G. A.)—Obituary, 346.
Keratophyres in U. S. A., 252.
Klinoäoisite, 237.
Knistersalz, 234.
Knopite, 158.
Knoblauch (H.)—Death of, 91.
Kohlmann (W.)—Cassiterite, 107.
Koken (—)—91.
Kraatz-Koschlau (K. v.) and Hackman (V.)—Elæolite-syenite, 246.
Kreider (D. A.) and Penfield (S. L.)—Identity of hydrofranklinite and chalcophanite; heavy fluid for separating minerals, 44.
Krenner (J. A.)—Lorandite, 32, 168.
Kühnite, chem., 10.
Kunz (G. F.)—Phosphorescent diamonds, 241.
Kyanite, cryst., Brazil, 84.
——— Himalayas, 142.

Laccolites, 156, 151.
Lacroix (A.)—Min. of France, 218.
——— Edingtonite and natrolite, 341.
Lamprophyre, Montana, 255.
Lapparent (A. de)—345.
Laumontite, constitution, 37.
Laurion (Greece), 43, 106, 108.
Lautarite, cryst., 104.
Lautite, 78.
Lawson (A. C.)—Basic orthoclase rock, 153.
Lawsonite, 157.
Leadhillite, Missouri, 103.

Digitized by Google

Leucite, constitution, 38.
——— - -rocks, 36, 255, 262.
Levynite, constitution, 37.
Lewis (W. J.)—Humite series, 137.
Lewisite, 80, 179.
Limestone of igneous origin, 250.
Lindesite, 105, 168.
Lindöite, 116.
Lindström (G.)—Edingtonite from Sweden, 341.
Lipari Is., rocks, 35, 255.
Liparite, Texas, 249.
Liroconite, chem., 3.
Litchfieldite, 47.
Lithical characters, 148.
Lithiophilite and triphylite, 158.
Liversidge (A.)—Gold, 101.
——————— Boleite from N. S. Wales, 165.
——————— Marshite, 236.
Lorandite, 32, 168.
Lossenite, 106.
Louis (H.)—Altaite from Burma, 215.
Luzonite, 77.

Machacamarca, Bolivia, 22.
McMahon (C. A.) — Biotite-kyanite-cordierite rock, 141.
Magmatic differentiation, 38, 112, 114, 251.
Malignite, 153.
Mallet (F. R.)—Nemalite, 211.
——————— Blödite, 314.
Marbles, 165, 187.
Marcasite and pyrites, constitution, 105.
Marsh (C. W.)—Marshite, 236.
Marshite, 236.
Martite, Brazil, 85.
Maskelyne (N. S.)—146.
——————— Morphology of crystals, 93.
Massachusetts, rocks, 252.
Massive minerals, 56.
Matthew (W. D.) — Lavas of New Brunswick, 253.
Manzeliite, 229, 82.
Melaconite, Bolivia, 23.
Merrill (G. P.)–Sandstone concretions, 42.
——————— Onyx marbles, 165.
——————— Gold in granite, 227.
——————— Rocks of Montana, 253.
——————— Asbestiform minerals, 341.
Metadesmine, 343.
Metamorphism of rocks, 247, 251, 256, 259.
Mica, Co. Dublin, 199.
——— -peridotites, Bengal, 117.
——— -syenite, Saxony, 259.
Michel (L.)—Hautefeuillite, 162.
——————— Artificial powellite, 164.
Miers (H. A.)—12, 146, 236.
——————— Cleveite and helium, vi.
——————— Obituary of J. D. Dana, 89.
——————— Indexing mineralogical literature, xvii.
——————— Simple names for the 32 types of crystal symmetry, xvii.
——————— A horizontal goniometer, xvii.
——————— British pseudomorphs, 263.
Milch (L.)—Lossenite, 106.
Mineral chemistry, 149.
Minerals, new names, 323.
Mineralogy, determinative, 219.
——————— Hintze's Handbuch, 217.
——————— of France, 218.
Minor (J. C., Jun.) & Penfield (S. L.) —Topaz, 41.
Mispickel, Bolivia, 23.
——————— Kirkcudbright, 15.
Missourite, 262.
Monazite, cryst., Brazil, 83.
——————— in rocks, 304.
Monchiquite, 262; Fernando Noronha, 171; Monchique, 247.
Montana, rocks, 251, 253, 262.
Monzonites, Tyrol, 155.
Mordenite, 38.
Moses (A. J.)—345.
Moss-gold, origin, 101.
Mügge (O.)—146.

Digitized by Google

Muthmann (W.) and Fakle (A. S.)—Schneebergite, 229.
Muscovite, constitution, 111.
——— Co. Dublin, 199.

Natrolite, constitution, 37.
——— Wales, 198.
Navarro (L. F.)—Quirogaite, 241.
Nemalite, Afghanistan, 211.
Nephelite, constitution, 112.
——— in a crystalline schist, 242.
——— Ontario, 46.
——— -syenite. *See* Elæolite.
Neptunite, 100.
Neumann (F. E.)—Obituary, 92.
New mineral names, 323.
New rock names, *See* Rocks.
Nickel sulphide ores, 39.
Nies (F.)—Death of, 146.
Nordenskiöld (G.)—Death of, 91.
Nordenskiöld (O.)—Edingtonite from Sweden, 341.
Nordmarkite, 114, 115.
Northupite, 159, 226.
Notes and comments, 32, 91, 146, 217, 346.

Obituary, S. Allport, 349.
——— V. Ball, 92.
——— J. D. Dana, 89.
——— G. A. Daubrée, 146.
——— A. Des Cloizeaux, 345.
——— P. Dudgeon, 30.
——— A. E. Foote, 146.
——— H. v. Foullon, 217.
——— A. H. Green, 147.
——— S. Haughton, 347.
——— M. F. Heddle, 345.
——— L. J. Igelström, 345.
——— F. Johnstrup, 32.
——— G. A. Kenngott, 346.
——— H. Knoblauch, 91.
——— F. E. Neumann, 92.
——— F. Nies, 146.
——— G. Nordenskiöld, 91.
——— J. W. Retgers, 217.
——— F. Sansoni, 91.
——— J, J. Steenstrup, 345.
Obituary, A. Streng, 217.
Oebbeke (K.)—91.
Offretite, 37.
Oligoclase, parting planes, 43.
Olivine and humite, 139.
——— group, chem , opt., 239.
Onyx marbles, 165, 187.
Opal, Australia, 244, iii.
Optical anomalies, topaz, 42; garnet, 239.
Ore deposits and magmatic differentiation, 38.
——— classification of, 112.
O'Reilly (J. P.)—Mica from Co. Dublin, 199.
Oriental alabaster, 165.
Osann (A.)—345. Chilian minerals, 104.
——— Elæolite-syenites, Texas, 248.
Osmiridium, occurrence, 39.

Paisanite, 249.
Palache (C.)—Crossite, 35.
Parting planes, felspar, 43.
——— corundum, 49.
Pearceite, 224.
Peck (F. B.)—Bournonite, 228.
Pegmatite, monazite, etc., in, 305.
Penfield (S. L.)—Canfieldite and argyrodite, 40.
——— Herderite, 42.
——— Penfieldite, 43.
——— ——— Cleavage and parting planes in oligoclase and albite, 43.
——— ——— Brush's Determinative Mineralogy, 14th Edit., 219.
——— ——— Pearceite and polybasite, 224.
——— ——— Calaverite, 236.
——— and Foote (H. W.)—Rœblingite, 343.
——— and Forbes (E. H.)—Olivine group, 239.
——— and Frenzel (A.)—Identity of chalcostibite and guejarite, 338.
——— and Howe (W. T. H.)—Chondrodite, etc., 161.

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Penfield (S. L.) and Kreider (D. A.)—Identity of hydrofranklinite and chalcophanite; heavy fluids for separating minerals, 44.
——————— and Minor (J. C., Junr.)—Topaz, 41.
——————— and Pratt (J. H.)—Lithiophilite and triphylite, 158.
——————— ———————
Thaumasite, 342,
Penfieldite, 43.
Percylite, artificial, 164.
Peridotites, ores in, 112; Bengal, 117; Montana, 254; Piedmont, 260.
Perofskite-magnetite-rock, Brazil, 117.
Petrical characters, 148.
Petrology and mineralogy, 56.
Petterd (W. F.)—Catalogue of minerals of Tasmania, 218.
Pharmacolite, chem., 7.
Phenakite, Bohemia, 107.
Phillipsite, constitution, 37.
Phonolite, Texas, 248.
Phosgenite, artificial, 164.
Phosphatic peridotites, Bengal, 117.
Phosphorescent diamonds, 241.
Phyllites, metamorphism of, 259.
Picotite-rock, N. S. Wales, 63.
Picrite, Devon, 154.
——— hornblende-, Montana, 254.
Pipra (India), corundum, 57.
Pirsson (L. V.)—Monchiquite, 262.
——————— and Weed (W. H.)—Highwood Mtns., Montana, 151.
——————— ——————— ———————
Missourite, 262.
Pirssonite, 226.
Pisani (F.)—Thaumasite, 343.
Pisanite, 240.
Pisek (Bohemia), 106.
Pisolite, Carlsbad (Bohemia), 189.
Pittman (E. F.)—Willyamite, 236.
Plagionite, cryst., 192.
Platania (G.)—Xiphonite, 168.
Platinum, occurrence, 39.
Plumbo-resinite, pseudomorphs, 272.
Point systems, 119.
Polybasite, cryst., 224.
Pope (W. J.)—Chemical crystallography, 95.
——— ——— ——— Determining optic axial angles, x.
Porro (C.)—Peridotites, Piedmont, 260.
Potassium natrolite, 111.
Powellite, artificial, 164.
Pratt (J. H.)—Northupite, pirssonite, and hanksite, 226.
——————— and Penfield (S. L.)—Lithiophilite and triphylite, 158.
——————— ——————— ——————— ———————
Thaumasite, 342.
Precious stones, 220.
Prehnite, Wales, 198.
Prior (G. T.)—Monchiquite from Fernando Noronha, 171.
——————— Composition of zirkelite, 180.
——————— and Hussak (E.)—Lewisite and zirkelite, 80.
——————— ——————— ——————— Derbylite, 176.
——————— ——————— Tripuhyite, 302.
——————— and Spencer (L. J.)—Augelite, 16.
——————— ——— ———————
Identity of andorite, sundtite, and webnerite, 286.
Prolectite, 139, 161.
Pseudobrookite, Limoges, 305.
Pseudogaylussite, 344.
Pseudomorphs, 23, 112, 235, 344.
——————— British, 263.
Ptilolite, 38.
Pyknometer, 66.
Pyrites and marcasite, constitution, 105.
——— Bolivia, 23, 293.
——— Brazil, 85.
Pyroaurite, Sweden, 163.
Pyrochlore, Sweden, 231.
Pyroxenite, Montana, 254; Piedmont, 260; Tyrol 155.
Pyrrhoarsenite, 106.
Pyrrhotite, cryst, 109.
——————— nickeliferous, 39.

Digitized by Google

Quiroguite, 241.

Rammelsberg (C. F.)—Handbuch der Mineralchemie, 149.
Ransome (F. L.)—Lawsonite, 157.
Rathite, 225.
Refractive indices, determining in thin sections, 245.
Regnolite, 77.
Regular growth of enargite and barytes, 75.
Retgers (J. W.)—Dune-sands of Holland, 113.
——— Heavy fluids for separation of minerals, 228.
——— Obituary, 217.
Retzian, 166.
Rhyolites, ancient, from N. America, 252, 253.
Riebeckite, cryst., 231.
Rinne (F.)—Artificial silica, 243.
——— — Dehydration of stibnite, 343.
Robertson (Miss M. W.)—Analyses of mica, 200.
Rocks, Introduction to study of, 148.
——— monazite, xenotime, &c., in, 304.
——— simple, 56.
——— new names; Cataforite, 115; Lindöite, 116; Malignite, 153; Missourite, 262; Paisanite, 249; Shonkinite, 151; Sölvsbergite, 115; Stubachite, 116; Sussexite, 116; Volcanite, 35.
Rœblingite, 343.
Ruby, Burma, 232.
Rutile, cryst., Brazil, 85.
Rutley (F.)—Globular forms of chalybite from Cornwall, x.

Salvadorite, 240.
Sands, sea- and dune-, 113.
Sandstone concretions, 42.
Sansoni (F.)—Obituary, 91.
Satin spar, Alston, 184.
Saussurite-gabbro, Zermatt, 256.
Saxonite, Montana, 254
Schäfer (R. W.)—Metamorphosed gabbros, etc., Zermatt, 256.
Schiller structure in corundum, 52.
Schimpff (W.)—Sylvite, 233.
Schneebergite = garnet, 229.
Schorl-rock, India, 61.
Schulten (A. de)—Artificial northupite, etc., 226.
Scolecite, constitution, 37.
Sears (J.)—Ancient lavas in Massachusetts, 252.
Serpentine as an original igneous product, 116.
Separation of minerals by heavy fluids, 44, 113, 228, 304.
Shonkinite, 151.
Silica, artificial form of, 243, 343.
Silver-thallium nitrate, 44, 228.
Sjögren (H.)—Fluid enclosures in gypsum, 44.
——— ——— Prolectite, 161.
——— ——— Caryinite and soda-berzeliite, 162.
——— ——— Pyroaurite, 163.
——— ——— Retzian, 166.
——— ——— Urbanite, 167.
——— ——— Tilasite, 229.
——— ——— Mauzeliite, 229, 83.
Soda-anorthite, 111.
——— -berzeliite, 163.
——— -nepheline-hydrate, 111.
Sodalite, constitution, 111.
——— -syenite, Montana, 151, 255.
Sollas (W. J.)—Riebeckite, 231.
Solution planes in corundum, 53.
Sölvsbergite, 115.
Spencer (L. J.)—Enargite, 69.
——— Alston satin spar and massive calcites and aragonites, 184.
——— Zinckenite and wolfsbergite, 188.
——— ——— Plagionite, stephanite, enargite, anglesite, 192.
——— ——— Identity of guejarite and wolfsbergite, x. 338.
——— List of new minerals, 323.
——— & Prior (G. T.)—Augelite, 16.
——— ——— ——— Identity of andorite, sundtite and webnerite, 286.

Digitized by Google

Stalactitic marbles, 165, 187.
Steenstrup (J. J. S.)—Death of, 345.
Stephanite, cryst., 196.
Stilbite, constitution, 37.
—— – dehydration, 343.
Streng (A.)—91; Obituary, 217.
Structure planes of corundum, 49.
Structures, homogeneous, 119.
Stubachite, 116.
Sulfoborite, 103.
Sulphur, native, origin of, 45.
Sulphides, heavy fluids for separating, 228.
Sulphosalts, cryst., 225.
Sulphuretted hydrogen enclosed in gypsum, 44; in sylvite, 233.
Sundtite=andorite, 286.
Sussexite, 116.
Sylvite, Stassfurt, 233.
Syntagmatite, 244.

Talmage (J. E.)—32.
Tasmania, minerals of, 218.
Texas, nephelite rocks, 248.
Thaddéeff (K.) and Arzruni (A.)—Celestite, 234.
Thaumasite, New Jersey, 342.
Thomson (J. S.) and Heddle (M. F.)—Delessite from Cantyre, 28.
Thomsonite, constitution, 37.
Thugutt (S. J.) — Constitution of alumino-silicates, 111.
Tiffanyite, 241.
Tilasite, 229.
Tinguaite, Christiania, 116; Monchique, 247; Texas, 249.
Tolstopiatow (M.)—Recherches minéralogiques, 97.
Topaz, chem., opt., 41.
—— cryst, 99.
Tourmaline, Burma, 233.
—— -rock, India, 61.
Trachybasalts, Fernando Noronha, 172.
Triphylite and lithiophilite, 158.
Tripuhy (Brazil), 83, 176.
Tripuhyite, 302.
Tutton (A. E.)—Instrument for cutting crystal sections, vi.
Twin lamellæ in corundum, 53.
Tyrol, rocks, 155.
Tyrolite, chem., 5.

Urbanite, 167, 105.
Ussing (N. V.)—91.

Valleite, 228.
Vicinal faces, augelite, 17.
Vienna Museum, guide to building materials, 34.
Viola (C.)—Determination of refractive power in thin sections, 245.
Vogt (J. H. L.)—Ore deposits and magmatic differentiation, 38.
—— Classification of ore deposits, 112.
Volcanite, 35.
Vrba (C.)—Beryl, etc., from Bohemia, 106.

Wardite, 226.
Warren (C. H.)—345.
Water enclosed in gypsum, 44.
—— of crystallisation, etc., 1, 46, 316.
Wax, mineral, Russia, 236.
Webnerite=andorite, 286.
Websterite, Montana, 254.
Weed (W. H.) and Pirsson (L. V.)—Highwood Mtns., Montana, 151; Missourite, 262.
Wehrlite, Montana, 254.
Weibull (M.)—Idocrase, 230.
Weidman (S.)—Ancient lavas in Wisconsin, 252.
Weinschenk (E.) — Serpentine-rocks, 116.
—— Epidote and zoisite, 237.
—— Garnet group, 238.
Wells (H. L.)—Leadhillite, 103.
Wichmann (A.)—Leucite rocks, Celebes, 36.
Willyamite, 236.
Wisconsin, ancient lavas, 252.
Wolfsbergite, cryst., 188.
—— Bolivia, Spain, 338.
Woodward (C. J.)—Lecture-room apparatus for crystallography, x.
—— Crystallography for beginners, 222.
Woodward (H. P.)—Geol. map of Western Australia, 32.

Xenotime, cryst., Brazil, 83.
—— in rocks, 304.
Xiphonite, 168.

Zeolites, constitution, 37.
Zermatt, rocks, 256.
Zinckenite group, 188.
—— Bolivia, 23.
—— Harz, 188.
Zircon, Brazil, 84.
—— in rocks, 304.
Zirconium and titanium, separation, 181.
Zirkelite, 86, 180.
Zoisite and epidote, 237.

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ERRATA.

VOL. II.

PAGE	LINE	
63	19	*for* Parjkull *read* Paijkull.

VOL. IV.

65	9	*for* 109° *read* 101°.

VOL. VI.

164	13*	*for* fig. 1 *read* fig. 2.
165	1*	*for* XI. *read* IX.
202	8	*for* Weardale, Cumberland, *read* Weardale, Durham.

VOL. VIII.

172	16*	*for* e{001} *read* c{001}.
184	7	*for* Ardbarrow Mine *read* Hodbarrow mine.
216	11	*for* 1 : 1 : 5613 *read* 1 : 1·5613.
	12	*for* 1 : 1 : 562 *read* 1 : 1·562.

VOL. X.

284	21	*for* Drigg in Cumberland *read* Dresden in Saxony.

VOL. XI.

2	15*	*for* analysis *read* analyses.
5	2	*for* XXVII. *read* XXVI.
10	9	*for* 8 *read* 7.
20	4	*for* acute angle *read* obtuse axial angle.
23	2* *(f. n.)*	*for* Castlenau *read* Castelnau.
32	12	*for* J. S. Talmage *read* J. E. Talmage.
44	10*	*for* Hy. Sjögren *read* Hj. Sjögren.
64	1* *(f. n.)*	*for* Calcium *read* Cæsium.
69	16*	*for* Éstesitö *read* Értesitő.

* From bottom of page.

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228

VOL. XI.—*Continued.*

PAGE	LINE	
70	2	*for* 1877 *read* 1878; *add* Vol. XXXV.
	12	*for* I., 159 *read* I., 159, Ref.
	11*	*for* 1878 *read* 1879; *add* Vol. VII.
71	6*	*for e* 403 (Dauber?) *read e* 403? (Dauber).
72	14	*for* L 132 (Dauber?) *read* L 132? (Dauber).
104	10	*for* $2Mg_2B_4O_9$ *read* $2Mg_3B_4O_9$.
105	5*	*for* $3RO.SiO_2.R_2O_3.SiO_2$ *read* $3(RO.SiO_2).R_2O_3.SiO_2$.
106	17	*for* A. C. Lossen *read* C. A. Lossen.
144	18	*for* rocks *read* rock.
151	3	*for* pp. 389-122 *read* 389-412.
168	14*	*for* 471 *read* 473.
178	20*	*for* $FeO.Sb_2O_5+5FeO.TiO_2$ *read* $FeO.Sb_2O_5+5(FeO.TiO_2)$.
191	9	*for* 0·6376 *read* 0·6377.
209	8	*for* 1899 *read* 1896.

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EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, November 20th, 1894.

Prof. N. S. Maskelyne, F.R.S., President, in the Chair.

The Earl of Berkeley, F.G.S., and Mr. William Barlow, F.G.S., were elected Members of the Society.

The death of the Rev. E. Hale and the resignation of Mr. A. Taylor were announced.

The names of two Members were removed from the list for non-payment of subscriptions.

The following dates were selected for the Meetings to be held during the year 1895:—February 5, April 2, June 18, and November 19 (Anniversary).

ANNIVERSARY MEETING.

Held in the Apartments of the Geological Society, November 20th, 1894.

Prof. N. S. Maskelyne, F.R.S., in the Chair.

Fifteen Members were present.

The following Report of Council for the Session 1893-4 was read by the Secretary:—

REPORT.

The Balance Sheet for the year ending December 31st, 1893, which was issued with Number 48 of the Journal, showed that the state of the finances continued to be satisfactory: the Assets (exclusive of the Stock of the Journal and the Library) amounting to £275 17s. 3d. The number of existing Members who had compounded before December 31st, 1893, for their Annual Subscription was 35.

During the session 1893-4, eight Members have been elected, two Members—the Rev. G. Gordon and the Rev. E. Hale—have died, and one Member has resigned: the names of two non-effective Members have been removed from the List for non payment of subscriptions.

The number of Members of the Society is now 127: of these, 106 are Ordinary Members, 21 are Corresponding Members.

Four Meetings have been held during the year, all in London, and (by kind permission) in the Apartments of the Geological Society, Burlington House.

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Two Numbers of the Journal, Nos. 47 and 48, have been issued since the last Anniversary Meeting. Two papers are contributed by Mr. Miers; one of them, written in conjunction with Mr. Prior, is an elaborate discussion of the characters and relations of the minerals Xanthoconite and Rittingerite, and is an appendix to the memoir on the Red Silvers published some years ago in the Magazine; the other describes a rare and beautiful mineral, Spangolite, of which only one specimen was previously known to exist. To Dr. Trechmann the Society is indebted for a paper giving the results of a careful examination of some excellent crystals of Binnite from Imfeld. A paper by Lieut.-Gen. McMahon discusses the optical characters of globules and spherulites of lithium phosphate and some other salts. Mr. Louis has contributed papers descriptive of the Ruby and Sapphire deposits of Moung Klung in Siam, and of the modes of occurrence of Gold: Professor Heddle and Mr. J. S. Thomson, a paper on the "Skin" of Agates: Mr. Rutley, descriptions of Fulgurites from Griqualand, inclusions in Quartz, and cavities in Zircon: Mr. Prior, an Analysis of Fergusonite from Ceylon: Mr. Harker, calculations relative to the extinction-angles in cleavage-flakes: Professors Liversidge and Ulrich, respectively, descriptions of the occurrence of Nantokite in New South Wales, and of Ruby and Margarite at Westland, in New Zealand. An elaborate chemical examination of a New Zealand meteoric stone sent to this country by Professor Ulrich has been made by Mr. Fletcher, whose paper gives the analytical processes and results in a more detailed and systematic manner than has been done by previous investigators, and in such a form as to relieve future analysts of such bodies of a considerable amount of toil.

The Numbers contain also many interesting abstracts of mineralogical papers published elsewhere; for these the Society owes its hearty thanks to Messrs. Harker, Prior, Rutley, and Spencer.

The elaborate Index to the volume has been made by Mr. Miers, who is sparing of no labour in his conduct of the Magazine.

The Society may now congratulate itself on the completion of the first ten volumes of the Journal, and on the maintenance of the high character of the Journal as a scientific publication.

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On the motion of the President, seconded by Dr. Hugo Müller, the Report of Council was adopted.

Mr. Kitto and Mr. Tutton, having been nominated to act as scrutineers, reported that 38 voting papers had been returned to the Secretary, and that the following list of Officers and Council was unanimously approved

President.	Prof. N. Story-Maskelyne, M.A., F.R.S.
Vice-Presidents.	Rev. Prof. S. Haughton, M.D , F.R.S.
	Dr. Hugo Müller, Ph.D., F.R.S.
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Foreign Secretary.	Prof. J. W. Judd, F.R.S.
General Secretary.	Mr. L. Fletcher, M.A., F.R.S.
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	Prof. C. Le Neve Foster, D.Sc., F.R.S.
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	Mr. A. E. Tutton, A.R.C.S., F.C.S
	Mr. W. W. Watts, M.A., F.G.S.

A vote of thanks to the Auditors (Mr. Kitto and Mr. Rutley) was passed, and the Auditors were re-elected.

Votes of thanks were also passed to the retiring Members of Council (the Rev. H. P. Gurney, Prof. Liveing, Lieut.-Gen. McMahon, and Mr. Teall), and to the Geological Society for the use of its Apartments.

The following papers were then read:—

1. On Cone-in-Cone Structure: by the Rev. Prof. T. G. Bonney, D.Sc., F.R.S. (Page 24.)

2. On a Basic Ferric Sulphate from Parys Mount, Anglesey: by Prof. A. H. Church, M.A., F.R.S. (Page 13.)

3. Augelite: by Mr. G. T. Prior, M.A., F.G.S., and Mr. L. J. Spencer, B.A., F.G.S. (Page 16.)

4. On the Occurrence of Delessite in Cantyre: by Professor M. F. Heddle, F.R.S.E., and Mr. J. S. Thomson. (Page 28.)

Specimens were exhibited in illustration of the paper on Augelite: also a beautiful opal-cast of a bivalve from Australia.

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Mineralogical Society—Abstract of Receipts and Payments from 1st January to 31st December 1894.

RECEIPTS.

	£ s. d.	£ s. d.
Balance from year 1893:—		
(1) In Bank	19 18 6	
(2) In Office	0 13 4	
		20 11 10
Subscriptions:—		
(1) In advance	4 4 0	
(2) Current	51 9 0	
(3) In arrear	8 8 0	
		64 1 0
Entrance Fees and Compositions		28 7 0
Sale of Journal:—		
(1) By Publishers	15 14 0	
(2) At Office	2 18 1½	
		18 12 1½
Dividends on Stock		7 6 8
Authors' extra separate copies		4 0 0
Donation for Illustration (Mr. Rutley)		1 16 3
		£144 14 10½

PAYMENTS.

	£ s. d.
Printing and Stationery	88 6 9
Illustrations	8 4 6
Attendance at Meetings	1 . 0
Editorial and Clerical Expenses	Nil
Postage, Parcels, &c.	1 10 9
Insurance of Stock of Journal	1 8 0
Investments and Commission	7 6 8
Bank Commission on Cheques	0 2 6
Stamps on 60 Cheques	0 5 0
Cash in Office on 31st December, 1894	2 3 2½
Balance in Bank on ditto	34 6 6
	£144 14 10½

Examined and compared with the vouchers and found correct. (Signed)

February 26th, 1895.

BENEDICT KITTO, } *Auditors.*
FRANK RUTLEY, }

LIABILITIES.

	£ s. d.
Printing and Stationery	4 19 7
Illustrations	0 13 6
Secretarial and Editorial Postage	0 6 6
Excess of Assets over Liabilities	382 6 1½
	£388 5 8½

The number of Life Members on December 31st, 1894, was 37.

ASSETS.

	£ s. d.
Balance at the Bank	34 6 6
Cash in Office	2 3 2½
Subscriptions for 1891-4 unpaid	29 8 0
Stock in 2¾ per cent.: £287 6s. 3d. at 104...	298 16 1
Dividend on Stock, January 1895	1 17 3
Sale of Journal	16 17 5
Due for Authors' separate Copies	4 17 3
	£388 5 8½

MEMO.—The Stock of Publications and the Library are not included in the above assets.

(Signed) F. W. RUDLER,

Treasurer.

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EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, February 5th, 1895.

Dr. Hugo Müller, F.R.S., Vice-President, in the Chair.

The death of Professor Johnstrup, Corresponding Member, was announced.

Dr. A. Brezina of Vienna, Professor C. Klein of Berlin, and Professor W. C. Brögger of Christiania, were elected as Corresponding Members of the Society.

GENERAL MEETING.

Held in the Apartments of the Geological Society, February 5th, 1895.

Dr. Hugo Müller, F.R.S., Vice-President, in the Chair.

Thirteen Members were present.

The following papers were read :—

1. On simple crystalline rocks from India and Australia: by Prof. J. W. Judd, F.R.S. (Page 56.)

2. On an accurate method of determining the densities of solids: by the Earl of Berkeley, F.G.S. (Page 64.)

3. Some points in the determination of the densities of minerals: by Prof. A. H. Church, F.R.S.

Specimens were exhibited by Prof. Judd in illustration of his paper, and a pyknometer was shown by the Earl of Berkeley.

EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, April 2nd, 1895.

Prof. N. S. Maskelyne, F.R.S., President, in the Chair.

The Rev. J. M. Gordon, F.G.S., was elected a Member of the Society.

The death of Mr. P. Dudgeon, one of the Trustees of the Society, was announced.

Mr. R. H. Scott, M.A., F.R.S., Past-President of the Society, was elected to the vacant Trusteeship.

GENERAL MEETING.

Held in the Apartments of the Geological Society, April 2nd, 1895.

Prof. N. S. Maskelyne, F.R.S., President, in the Chair.

Thirteen Members and two visitors were present.

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The following papers were read :—

1. Notes on Enargite, by Mr. L. J. Spencer, B.A., F.G.S. (Page 69.)

2. An instrument for cutting, grinding, and polishing accurately-orientated section-plates and prisms of mineral and other crystals: by Mr. A. E. Tutton, A.R.C.S., F.C.S.

A specimen of enargite was shown by Mr. Spencer in illustration of his paper; and the cutting machine was exhibited in action by Mr. Tutton, an electro-motor being employed.

Specimens of lorandite and cleveite were shown by Mr. Miers, who mentioned how a communication made by him to Prof. Ramsay relative to Dr. Hillebrand's work on the latter mineral had led to the discovery of a gas giving a spectrum including the helium line.

EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, June 18th, 1895.

Dr. Hugo Müller, F.R.S., Vice-President, in the Chair.

The death of Prof. J. D. Dana, Corresponding Member of the Society, was announced.

Prof. J. Geikie, Mr. Hutchinson, Mr. Kitto, and Lieut.-General McMahon were selected for nomination to replace the four retiring Members of Council.

GENERAL MEETING.

Held in the Apartments of the Geological Society, June 18th, 1895.

Dr. Hugo Müller, F.R.S., Vice-President, in the Chair.

Twelve Members were present.

The following paper was read :—

On two new minerals, Lewisite and Zirkelite, from Brazil: by Dr. E. Hussak and Mr. G. T. Prior, M.A., F.G.S. (Page 80.)

Specimens of these minerals were exhibited in illustration of the above paper by Mr. Prior, who also referred to a new titano-antimonate of iron, of which a preliminary examination had been made.

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EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, November 19th, 1895.

Prof. N. S. Maskelyne, F.R.S., President, in the Chair.

Mr. R. C. Webb and the Rev. Mark Fletcher were elected Ordinary Members of the Society.

ANNIVERSARY MEETING.

Held in the Apartments of the Geological Society, November 19th, 1895.

Prof. N. S. Maskelyne, F.R.S., President, in the Chair.

Seventeen Members and three visitors were present.

The following Report of Council for the Session 1894-5 was read by the Secretary :—

REPORT.

The Balance Sheet for the year ending December 31st, 1894, which was issued with Number 49 of the Journal, showed that the state of the finances of the Society continued to be eminently satisfactory : the Assets (exclusive of the Stock of the Journal and the Library) amounting to £382 6s. 1½d. The number of existing Members who had compounded before December 31st, 1894, for their Annual Subscription was 37.

During the Session 1894-5, one Member, Mr. Patrick Dudgeon, for many years a Trustee of the invested funds of the Society, has been removed by death ; two new Members have been elected ; two Corresponding Members (Professors Johnstrup and J. D. Dana) have died ; and three new Corresponding Members (Dr. Brezina, Professors Klein and Brögger) have been added to the List. The number of Members of the Society is now 132 : of these, 110 are Ordinary Members and 22 are Corresponding Members.

Mr. R. H. Scott, M.A., F.R.S., Past-President of the Society, was appointed to the Trusteeship vacated through the death of Mr. Dudgeon.

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Four Meetings have been held during the year, all in London, and (by kind permission) in the Apartments of the Geological Society, Burlington House.

Two Numbers of the Journal, Nos. 49 and 50, have been issued since the last Anniversary Meeting. The principal papers in No. 49 were those by Professor Church and Messrs. Prior and Spencer. The former author gave the Society an account of various researches which he had made into the chemical composition of certain native arsenates and phosphates, particular attention being paid to the degree of tenacity with which the water of the hydrous species was held: Professor Church also described a basic ferric sulphate from Anglesey. Messrs. Prior and Spencer gave a careful description, chemical and crystallographic, of a rare mineral from Bolivia, Augelite, a hydrous aluminium phosphate. To the same Number Professor Bonney contributed a note on cone-in-cone structure, pointing out that the structure, though primarily due to crystallisation, owes its development to contraction subsequent thereto. Mr. Dudgeon placed on record the occurrence of mispickel in the Stewartry of Kirkcudbright, and Professor Heddle and Mr. Thomson described the mode of occurrence and the characters of Delessite in Cantyre. No. 50 contained an important paper by Professor Judd, in which he showed that corundum has three sets of structure-planes, but that none of them can be regarded as true cleavage. The same author described the occurrence of corundum-rock, and of other large masses, each consisting essentially of material belonging to a single mineral species. The Earl of Berkeley contributed the result of his study of the methods of accurately determining the densities of crystals. An elaborate paper by Mr. Spencer recorded his researches into the mineralogical characters of Enargite; while Dr. Hussak and Mr. Prior described two new minerals—Lewisite, a titano-antimonate of calcium and iron; and Zirkelite, a zirconate and titanate of calcium.

The Abstracts in the two Numbers have been of an interesting and useful character: for these the Society is indebted to the kindness of Messrs. Harker and Spencer.

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On the motion of the Chairman, seconded by Mr. Scott, the Report of the Council was adopted.

Mr. Rudler and Mr. Pringle were nominated scrutineers; they reported that 28 voting papers had been returned, and that the following list of Officers and Council had been unanimously approved

President.	Prof. N. S. Maskelyne, F.R.S.
Vice-Presidents.	Rev. S. Haughton, M.D., .R.S.
	Dr. Hugo Müller, F.R.S.
Treasurer.	Mr. F. W. Rudler, F.G.S.
Foreign Secretary.	Prof. J. W. Judd, F.R.S.
General Secretary.	Mr. L. Fletcher, F.R.S.
Ordinary Members of Council.	Prof. J. Geikie, LL.D., F.R.S., L. & E.
	Mr. A. Hutchinson, M.A., Ph.D.
	Mr. B. Kitto, F.G.S.
	Lieut.-Gen. C. A. McMahon, F.G.S.

In addition to the members not requiring re-election, Prof. Green, Mr. Harker, Prof. Lewis, Mr. Pringle, Mr. Prior, Mr. Thomson, Mr. Tutton and Mr. Watts; and in place of the retiring Members, Prof. Church, Prof. Le Neve Foster, Mr. Miers and Prof. Macadam.

Messrs. J. H. Collins and B. Kitto were elected Auditors of the accounts of the Society.

A vote of thanks to the Geological Society for the use of its Apartments was carried with acclamation.

The following paper was read :—

On Homogeneous Structures and the symmetrical partitioning of them: by Mr. William Barlow, F.G.S. [p. 119]. The paper was illustrated by numerous models: Professor Herschel submitted for inspection a large series of models bearing upon the same subject.

EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, February 4th, 1896.

Mr. W. W. Watts, M.A., F.G.S., in the Chair.

The resignation of Mr. Vaughan Hughes was accepted.

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GENERAL MEETING.

Held in the Apartments of the Geological Society, February 4th, 1896.

Mr. W. W. Watts, M.A., F.G.S., in the Chair.

Thirteen Members were present.

The following papers were read :—

1. On fibrous and massive forms of Calcite and Aragonite: by Mr. L. J. Spencer.

2. On associated globular and rhombohedral forms from Botallack, Cornwall: by Mr. F. Rutley.

3. On the occurrence of rocks allied to Monchiquite at Fernando Noronha: by Mr. G. T. Prior.

4. On a method of determining the optic axial angle in cases where plate is oblique to a bisectrix: by Mr. W. J Pope.

Specimens were exhibited in illustration of the last three papers. Mr. Pope also demonstrated the phosphorescence resulting from fracture of crystals of saccharin, a property of the substance discovered by him.

EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, April 14th, 1896.

Prof. N. S. Maskelyne, F.R.S., President, in the Chair.

The resignation of Mr. Townshend Hall was announced.

GENERAL MEETING.

Held in the Apartments of the Geological Society, April 14th, 1896.

Prof. N. S. Maskelyne, F.R.S., President, in the Chair.

Fifteen Members and two visitors were present.

The following papers read :—

1. Some lecture-room apparatus for illustrating the elementary principles of Crystallography: by Mr. C. J. Woodward.

2. On Wolfsbergite from Bolivia, and the probable identity of Wolfsbergite and Guejarite: by Mr. L. J. Spencer.

3. On some hitherto undescribed British pseudomorphs: by Professor H. A. Miers.

4. Note on the relations of Enstatite and Olivine to the Humite group: by Professor W. J. Lewis.

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5. On the Micas of the Three Rock Mountain, County Dublin, and on the presence of copper in the mica of Glencullen, County Wicklow: by Professor J. P. O'Reilly (communicated by Mr. F. Rutley).

Mr. Woodward showed a convenient method of marking zones on a blackened india-rubber ball, constructed crystal figures on a blackboard by stretching coloured elastic bands round pins inserted at particular points in the board, and exhibited an adjustable triad of coloured rods representing crystallographic axes.

EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, June 23rd, 1896.

Prof. N. S. Maskelyne, F.R.S., President, in the Chair.

The death of M. Daubrée, corresponding Member, was announced.

Mr. Louis Wills was elected to the ordinary Membership of the Society.

Mr. Barlow, Prof. Church, Mr. Miers, Mr. Pope, were selected for nomination to replace the four retiring Members of the Council (Messrs. Lewis, Pringle, Prior and Thomson).

GENERAL MEETING.

Held in the Apartments of the Geological Society, June 23rd, 1896.

Prof. N. S. Maskelyne, F.R.S., President, in the Chair.

Fourteen Members were present.

The following papers were read:—

1. Notes on a biotite-cyanite-cordierite rock from the Upper Satlej Valley, N.W. Himalayas: by Lieut.-Gen. C. A. McMahon, V.P.G.S. [p. 141].

2. Homogeneous structures that cannot be partitioned into cells which are all of the same shape without impairing the symmetry (illustrated by models): by William Barlow, Esq.

The Secretary submitted for inspection a specimen of the noble opal from New South Wales, and three specimens of the Swedish mineral reported to be chemically identical with the Scotch Edingtonite, but to be orthorhombic and optically biaxial.

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Mineralogical Society—Abstract of Receipts and Payments from 1st January to 31st December 1895.

RECEIPTS.

	£ s. d.	£ s. d.
Balance from year 1894		36 9 8½
Subscriptions:—		
(1) In advance	4 1 0	
(2) Current	49 7 4	
(3) In arrear	11 11 6	
		64 19 10
Entrance Fees and Compositions		47 5 0
Sale of Publications in Office		0 5 8
Dividends on Stock		7 14 0
		£156 14 2½

PAYMENTS.

	£ s. d.	£ s. d.
Printing and Stationery		55 7 3
Illustrations		0 18 0
Binding Books for Library		6 2 0
Attendance at Meetings		1 1 0
Insurance of Stock		3 2 6
Investments and Commission		6 18 6
Fees in connection with change of Trustee		0 15 6
Commission on Cheques		0 2 0
Balance at Bank	£82 3 3	
In Office	0 4 2½	
		82 7 5½
		£156 14 2½

Examined and compared with the vouchers and found correct. (Signed)

BENEDICT KITTO, } *Auditors.*
J. H. COLLINS, }

February 13th, 1896.

LIABILITIES.

	£ s. d.
Secretarial Postage	1 6 5
Excess of Assets over Liabilities	459 10 11½
	£460 17 4½

The number of Life Members on December 31st, 1895, was 34.

ASSETS.

	£ s. d.
Balance as above	82 7 5½
Subscriptions for 1893-5 unpaid	10 0 0
Stock in 2¾ Consols: £293 12s. 2d. at 108	317 3 0
Dividend on Stock, January 1896	1 19 0
Sale of Journal due from Publishers, 1894	16 17 5
Ditto ditto 1895	24 16 11
Due for Authors' Copies	7 13 7
	£460 17 4½

Memo.—The Stock of Publications and the Library are not included in the above assets.

(Signed) F. W. RUDLER,
Treasurer.

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EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, November 17th, 1896.

Dr. Hugo Müller, F.R.S., Vice-President, in the Chair.

The death of Professor A. H. Green, F.R.S., Member of the Society, was announced.

Mr. Thomas Henry Holland, F.G.S., A.R.C.S., Superintendent of the Geological Survey of India, was elected an Ordinary Member of the Society.

ANNIVERSARY MEETING.

Held in the Apartments of the Geological Society, November 17th, 1896.

Dr. Hugo Müller, F.R.S., Vice-President, in the Chair.

Twelve Members and two visitors were present.

The following Report of Council for the Session 1895-6 was read by the Secretary :—

REPORT.

The Balance Sheet for the year ending December 31st, 1895, which was issued with Number 51 of the Journal, showed that the state of the Finances of the Society continued to be very satisfactory : the Assets (exclusive of the Stock of the Journal and the Library) amounting to £460 17s. 4d., and the only Liability being £1 6s. 5d. (for postage). The number of existing Members who had compounded before December 31st, 1895, for their Annual Subscription, was 34.

During the Session 1895-6, one Ordinary Member (Professor Green), and one Corresponding Member (Professor Daubrée), have been removed by death ; two new Members, Messrs. Wills and Holland, have been elected, and two Members, Messrs. Hall and V. Hughes have resigned. The number of Members of the Society is now 130 : of these, 109 are Ordinary Members and 21 are Corresponding Members.

Four Meetings have been held during the year, all in London, and (by kind permission) in the Apartments of the Geological

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Society, Burlington House. The attendances at these Meetings have been 14, 17, 13 and 17, respectively.

Two Numbers of the Journal have been issued since the last Anniversary Meeting. The first of these is an Index of Authors and Subjects for the ten volumes of the Journal which have now been published: the preparation of the Index, which extends to 88 pages of closely printed matter, was undertaken as a labour of love by Mr L. J. Spencer, to whom the hearty thanks of the Society are due. The other, Number 51, contains papers by Mr. Barlow, Professor Lewis and Lieut.-Gen. C. A. McMahon. Mr. Barlow's paper deals with homogeneous structures and the symmetrical partitioning of them, with application to crystals; it is accompanied by two elegant plates by the help of which illustrative models can be constructed for the use of the reader: the paper will be very acceptable wherever crystallography is deeply studied. Professor Lewis's paper on the Humite Series suggests various points of morphological similarity of the members of that series to one another and to olivine and enstatite. Lieut.-Gen. McMahon's paper is descriptive of a biotite-cyanite-cordierite rock, from the Upper Satlej Valley, in the North-West Himalayas, and discusses the mode of origin of such a rock. The same number contains a useful series of Abstracts for which the Society is indebted to Messrs. Harker, Prior and Spencer.

During the year the Stock of the Journal has been transferred to the custody of the Secretary, and the Insurance has been dropped.

The Council has to congratulate the Society on the continued steady sale of the Journal.

On the motion of the Chairman, seconded by Professor Miers, the Report of the Council was adopted.

Mr. Kitto and Mr. Pringle, having been nominated by the Chairman to act as scrutineers, reported that 31 voting papers had been returned, and that the following list of Officers and Council had been unanimously approved,

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President.	Prof. N. S. Maskelyne, F.R.S.
Vice-Presidents.	Rev. S. Haughton, M.D., F.R.S.
	Dr. Hugo Müller, F.R.S.
Treasurer.	Mr. F. W. Rudler, F.G.S.
General Secretary.	Mr. L. Fletcher, F.R.S.
Foreign Secretary.	Prof. J. W. Judd, F.R.S.
Ordinary Members of Council.	Mr. W. Barlow, F.G.S.
	Prof. A. H. Church, F.R.S.
	Prof. J. Geikie, F.R.S.
	Mr. A. Harker, F.G.S.
	Mr. A. Hutchinson, F.C.S.
	Mr. B. Kitto, F.G.S.
	Prof. W. J. Lewis, F.C.S.
	Prof. H. A. Miers, F.R.S.
	Lieut.-Gen. C. A. McMahon, F.G.S.
	Mr. W. J. Pope, F.C.S.
	Mr. A. Tutton, F.C.S.
	Mr. W. W. Watts, F.G.S.

Mr. J. H. Collins and Mr. B. Kitto were elected Auditors of the accounts of the Society.

Votes of thanks to the Geological Society for the use of its Apartments and to the retiring Members of Council were carried with acclamation.

The following papers were then read:—

1. Notes on the analysis of Zirkelite and Derbylite: by Mr. Prior (pp. 176, 180).

2. On some crystals of Iron Pyrites from Cornwall: by Mr. Hutchinson.

3. *a.* Zinckenite and Wolfsbergite (Chalcostibite) from Wolfsberg in the Harz: and the Zinckenite Group (p. 188).

b. The Crystallography of Plagionite: new crystal forms on Stephanite, Enargite and Anglesite (p. 192): both by Mr. Spencer.

4. Discovery of Prehnite in Wales: by Mr. Harrison, communicated by Prof. Miers (p. 198).

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EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, February 2nd, 1897.

N. S. Maskelyne, Esq., F.R.S., President, in the Chair.

Mr. Wm. Phipson Beale, Q.C., F.G.S., F.C.S., was elected a Member of the Society.

GENERAL MEETING.

Held in the Apartments of the Geological Society, February 2nd, 1897.

N. S. Maskelyne, Esq., F.R.S., President, in the Chair.

Eleven Members and one visitor were present.

The following papers were read:—

1. Note on Altaite from Burma: by Professor Henry Louis, M.A., F.G.S. (p. 215).

2. On Nemalite from Afghánistán: by Mr. F. R. Mallet, F.G.S. (p. 211).

3. On Derbylite, a new mineral from Brazil: by Dr. E. Hussak and Mr. G. T Prior (p. 176).

4. On Homogeneous Structures and Circular Polarisation: by Mr. William Barlow, F.G.S.

5. On Crystals of Calcite from Cleator Moor: by Mr. A. Hutchinson, Ph.D., F.C.S.

Mr. Barlow showed a model in illustration of his paper.

A small mass of a new meteoric iron, a large facetted beryllonite, and a fragment of pyrope showing an enclosed crystal of peridot were exhibited by Mr. W. E. Hidden.

EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, April 6th, 1897.

N. S. Maskelyne, Esq., F.R.S., President, in the Chair.

The audited Balance Sheet for the year ending December 31st, 1896, was submitted and approved: the Secretary was instructed to insert it in the Minutes as usual, and to issue a printed copy with the next Number of the Journal.

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Mr. G. F. Herbert Smith and Mr. H. L. Bowman were elected Members of the Society.

The date of the next Meeting was changed from June 22nd (General Holiday) to June 17th.

Prof. Miers and Mr. Spencer were appointed to assist in the classification of mineralogy for the proposed International Catalogue of Scientific Literature.

GENERAL MEETING.

Held in the Apartments of the Geological Society, April 6th, 1897.

N. S. Maskelyne, Esq., F.R.S., President, in the Chair.

Fourteen Members and one Visitor were present.

The following papers were read :—

1. On a new occurrence of Apophyllite in South Africa: by Mr. J. A. L. Henderson, M.E.

2. On Webnerite from Hungary: by Mr. G. T. Prior and Mr. L. J. Spencer.

3. On the Indexing of Mineralogical Literature: by Prof. Miers.

4. Some simple names for the 32 types of Crystal-symmetry: by Prof. Miers.

5. On Epidote from the Mourne Mountains: by Mr. A. Hutchinson.

Prof. Le Neve Foster exhibited a garnet enclosing a crystal of diamond found in the Orange Free State, and Prof. Miers a new form of horizontal-goniometer for the use of Students.

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Mineralogical Society—Abstract of Receipts and Payments from 1st January to 31st December 1896.

RECEIPTS.

	£ s. d.	£ s. d.
Balance from year 1895		82 7 5½
Subscriptions:—		
(1) In advance	1 1 0	
(2) Current	40 19 4	
(3) In arrear	5 5 0	
		47 5 4
Entrance Fees and Compositions		23 2 0
Sale of Publications:		
(1) From Publishers (two years) ...	41 14 4	
(2) In Office	0 19 1½	
		42 13 5½
Dividends on Stock		8 16 0
		£204 4 3

PAYMENTS.

	£ s. d.	£ s. d.
Printing and Stationery		77 5 6
Illustrations		5 6 3
Purchase of Serials to complete series		7 8 4
Attendance at Meetings		1 1 0
Insurance of Stock for three months		1 11 3
Carriage on removal of Stock		0 8 0
Secretarial Postage (two years)		2 7 5
Commissions on Cheques		0 2 0
Investments and Commission		58 16 0
Balance at Bank	£49 12 8	
„ in Office	0 5 4	
		49 18 0
		£204 4 3

Examined and compared with the vouchers and found correct. (Signed)

March 10th, 1897.

BENEDICT KITTO, J. H. COLLINS, } *Auditors.*

LIABILITIES.

	£ s. d.
Printing	3 7 8
Binding	19 0 9
Periodicals	0 13 0
Excess of Assets over Liabilities	474 19 6
	£498 0 11

The number of Life Members on December 31st, 1896, was 39.

ASSETS.

	£ s. d.
Balance as above	49 18 0
Subscriptions for 1894-6 unpaid	22 0 0
Stock in 2¾ Consols: £347 6s. 7d. at 112	389 3 2
Dividend on Stock, January 1897	2 6 2
Sale of Journal due from Publishers	25 7 0
Due for Authors' Copies	9 6 7
	£498 0 11

MEMO.—The Stock of Publications and the Library are not included in the above assets:

(Signed) F. W. RUDLER,

Treasurer.

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EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, June 17th, 1897.

Prof. A. H. Church, F.R.S., in the Chair.

The death of Professor Des Cloizeaux, Foreign Member, was announced.

Professor W. J. Sollas and Mr. E. Woollett were elected Members of the Society.

Prof. Liveing, Mr. Mallet, Mr. Prior, and Mr. Rutley were selected for nomination to replace the four retiring Members of the Council (Prof. Lewis, Mr. Harker, Mr. Watts, and Mr. Tutton).

GENERAL MEETING.

Held in the Apartments of the Geological Society, June 17th, 1897.

N. S. Maskelyne, Esq., F.R.S., President, in the Chair.

Eleven Members were present.

The following papers were read:—

1. On Blödite from the Punjab: by Mr. F. R. Mallet (p. 311).

2. On Monazite and Xenotime in European Rocks: by Mr. Orville A. Derby (communicated by the General Secretary), p. (304).

3. On the identity of Sundtite and Webnerite: by Messrs. G. T. Prior and L. J. Spencer (p. 286).

4. On a new antimonate of iron from Brazil: by Dr. E. Hussak and Mr. G. T. Prior (p. 302).

EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, November 16th, 1897.

The deaths of Professor Steenstrup, Corresponding Member, and the Reverend Professor Haughton, Vice-President of the Society, were announced.

Professor E. S. Dana, of Yale College, New Haven, Connecticut, U.S.A., was elected a Corresponding Member.

The Honourable A. J. Strutt, B.A., was elected a Member of the Society.

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The following Tuesdays were selected for the dates of Meeting in 1898:—February 1st, April 5th, June 21st, and November 15th (Anniversary).

The Draft Annual Report was amended and approved.

The proposal for an exchange of publications with the Edinburgh Geological Society was accepted.

ANNIVERSARY MEETING.

Held in the Apartments of the Geological Society, November 16th, 1897.

Prof. N. S. Maskelyne, F.R.S., President, in the Chair.

Fifteen Members were present.

The following Report of Council for the Session 1896-7 was read by the General Secretary:--

REPORT.

The Balance Sheet for the year ending December 31st, 1896, which was issued with Number 52 of the Journal, showed that the state of the Finances of the Society continued to be very satisfactory: the Assets (exclusive of the Stock of the Journal and the Library) amounting to £498 0s. 11d., and the Liabilities to £23 1s. 5d. The number of actual Members who had compounded before December 31st, 1895, for the payment of their Annual Subscription was 39.

During the Session 1896-7 there has been one loss by death (the Vice-President, Rev. S. Haughton, M.A., F.R.S.) from the List of Ordinary Members, and the Society has also to regret the deaths of two Corresponding Members, Professors Des Cloizeaux and Steenstrup: on the other hand, Professor E. S. Dana, of Yale College, U.S.A., has been elected a Corresponding Member, and six Ordinary Members have been elected to the Society. The total number of Members is now 134: of these 114 are Ordinary Members, and 20 are Corresponding Members.

Four Meetings have been held during the year, all in London, and (by kind permission) in the Apartments of the Geological Society, Burlington House. The attendances at these Meetings have been 14, 12, 15 and 11, respectively.

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Only one Number of the Journal (published in May) has been issued since the last Anniversary Meeting. To this Mr. Prior contributed a preliminary paper recording the occurrence of rocks allied to Monchiquites in the Island of Fernando Noronha, and also analyses of the new minerals Derbylite and Zirkelite discovered by Dr. Eugen Hussak in Brazil. Mr. Spencer described the Satin Spar of Alston, and made some suggestions as to the modes of discrimination of massive fibrous specimens of calcite from those of aragonite: to this author the Society is further indebted for critical accounts of Zinckenite, Wolfsbergite, and Plagionite: his suggestion of the identity of the species Guejarite with Wolfsbergite has since been accepted by Professor Penfield, who was already engaged in the investigation of a mineral supposed to be Guejarite. The number also contains an elaborate paper by Professor O'Reilly on the Micas of the Three Rock Mountain, County Dublin, to which his attention had been attracted by the zonal structure: this paper is illustrated by four fine plates, one of them coloured. Further, Mr. Mallet has recorded the results of his chemical and optical examinations of Nemalite from Afghanistan, and Professor Louis the occurrence of Altaite in Burma. For the numerous Abstracts the Society owes its hearty thanks to Messrs. Harker, Prior and Spencer.

The Council has to congratulate the Society on the continued steady sale of the Journal.

On the motion of the President, seconded by the General Secretary, the Report of the Council was adopted.

Mr. Kitto and Mr. Herbert Smith, having been nominated by the President to act as Scrutineers, reported that 30 voting papers had been returned, and that the following list of Officers and Council had been unanimously approved:—

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President.	Prof. N. S. Maskelyne, F.R.S.
Vice-President.	Mr. Hugo Müller, Ph.D., F.R.S.
Treasurer.	Mr. F. W. Rudler, F.G.S.
General Secretary.	Mr. L. Fletcher, F.R.S.
Foreign Secretary.	Prof. J. W. Judd, F.R.S.
Ordinary Members of Council.	Prof. J. Geikie, LL.D., F.R.S.
	Mr. A. Hutchinson, M.A., Ph.D.
	Mr. B. Kitto, F.C.S.
	Lieut.-Gen. C. A. McMahon, F.G.S.
	Mr. W. Barlow, F.G.S.
	Prof. A. H. Church, M.A., F.R.S.
	Prof. H. A. Miers, M.A., F.R.S.
	Mr. W. J. Pope, F.C.S.
	Prof. G. D. Liveing, M.A., F.R.S.
	Mr. F. R. Mallet, F.G.S.
	Mr. G. T. Prior, M.A., F.G.S.
	Mr. F. Rutley, F.G.S.

Mr. J. H. Collins and Mr. B. Kitto were re-elected Auditors of the accounts of the Society.

Votes of thanks to the Geological Society for the use of its Apartments and to the retiring Members of Council, Professor Liveing, Mr. Mallet, Mr. Prior and Mr. Rutley, were carried with acclamation.

The following Paper was then read:—

On Augelite from a new locality in Bolivia: by Mr. L. J. Spencer, M.A., F.G.S.

Mr. Hutchinson gave an account of an excursion to the Mourne Mountains, with Professor Lewis and a party of students, in search of minerals. Excellent Manebach twins of felspar and specimens of beryl, topaz and other minerals, obtained during the excursion were exhibited.

Prof. Miers gave an account of visits to various districts in Canada, more especially to view a vein of a mineral resembling Albertite, to the nickel formation at Sudbury, and to the gold mines of Kootenay, British Columbia.

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